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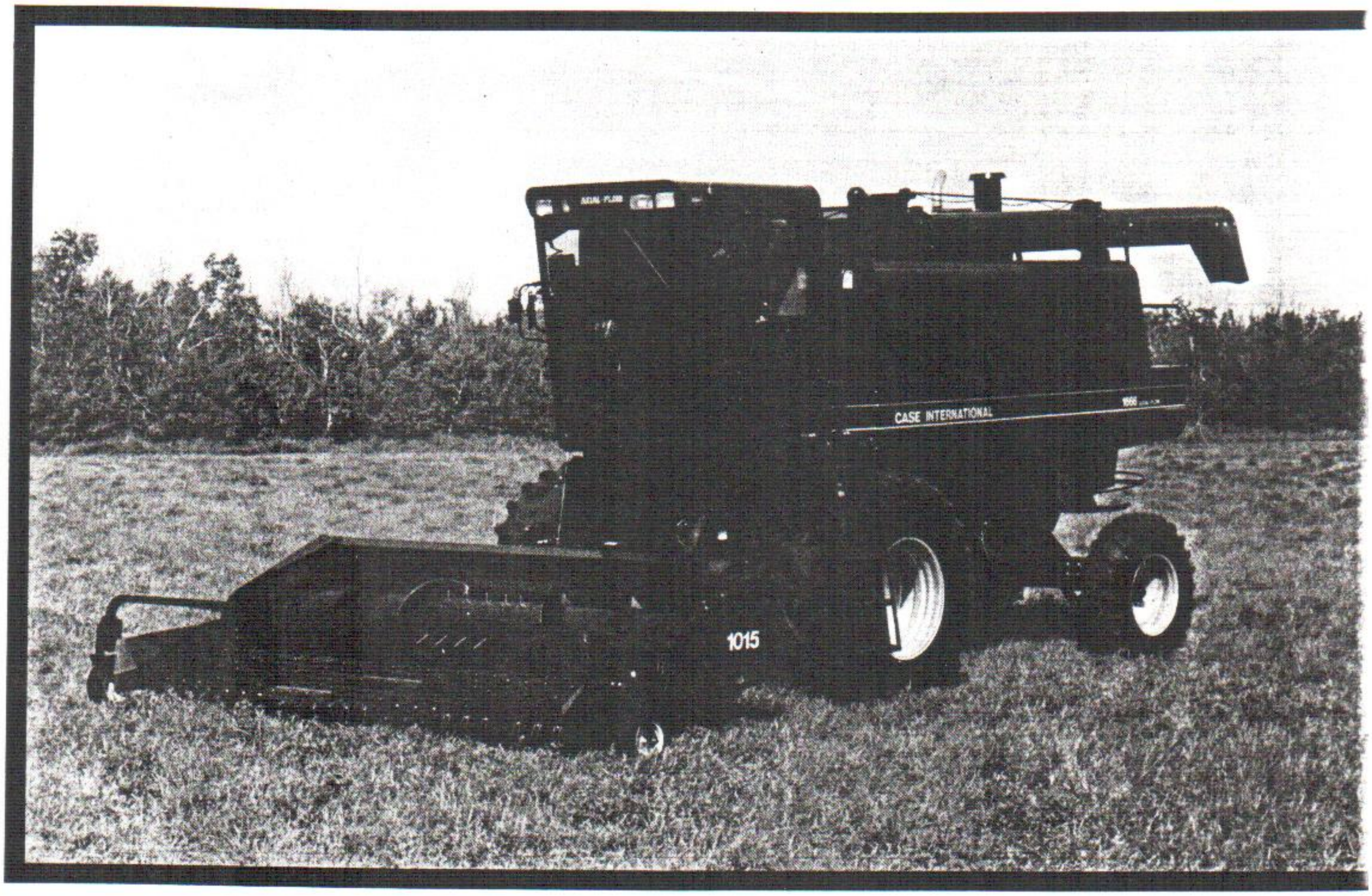
Evaluation Report 710



Case IH 1666 Combine

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

CASE IH 1666 COMBINE

MANUFACTURER:
JI Case Company
700 State Street
Racine, Wisconsin 53404
U.S.A.
Telephone: (414) 636-7530

DISTRIBUTOR:
JI Case Company
P.O. Box 5051
240 Henderson Drive
Regina, Saskatchewan
S4P 3M3
Telephone: (306) 924-1600

RETAIL PRICE:
$ 160,190.00 [April, 1993, f.o.b. Humboldt, Sask., with a 13 ft (4.0 m) pickup, powered rock beater with rock trap, wide and narrow wire spaced concaves, specialty rotor, grain scan monitor, 14.3 ft (4.4 m) unloading auger, straw spreader and AM-FM cassette radio].

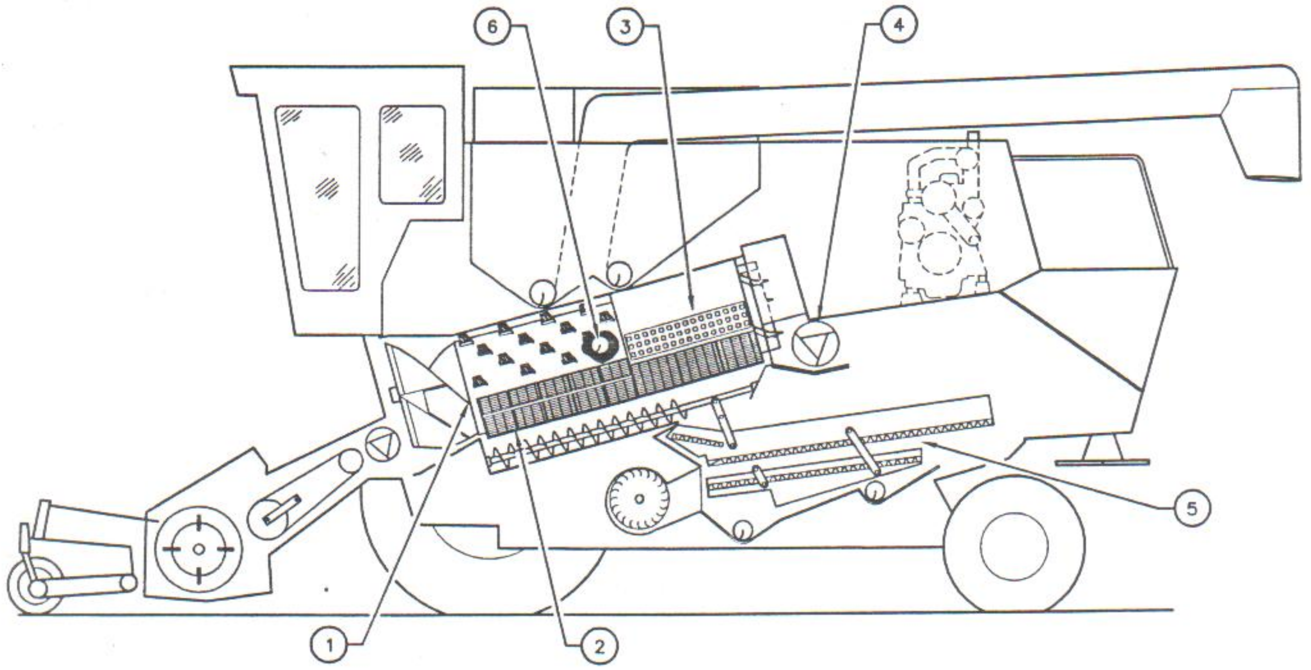


FIGURE 1. Case IH 1666: (1) Rotor, (2) Threshing Concaves, (3) Separating Concaves, (4) Discharge Beater, (5) Cleaning Shoe, (6) Tailings Return.

SUMMARY AND CONCLUSIONS

Capacity: In the capacity tests, the MOG feedrate[1] at 3% total grain loss in Manley and 1602 barley was 765 lb/min (20.8 t/h) and 660 lb/min (18.0 t/h), respectively. The MOG feedrate at power limit (1.5% total loss) was 800 lb/min (21.8 t/h) in Hero rapeseed. Combine capacity was 660 lb/min (18.0 t/h), 705 lb/min (19.2 t/h), and 700 lb/min (19.1 t/h) in Biggar, Katepwa, and Laura wheat respectively.

In the Manley and 1602 barley, the Case IH 1666 had respectively 1.5 and 1.6 times the capacity of the PAMI Reference II combine when compared at 3% total grain loss. The capacity in Hero rapeseed at power limit was the same as the Reference II at 3% total loss. In the wheat tests, the capacity of the Case 1666 was 1.4, 1.3, and 1.2 times that of the Reference II in the Biggar, Katepwa, and Laura crops.

Quality of Work: Picking performance was good in most crops. However, some crop was not picked when picking short straw windrows that had settled to the ground. The draper occasionally plugged with short, damp barley straw.

Feeding was good. The table auger was effective in conveying the windrow to the feeder opening, and the feed conveyor was aggressive in conveying the windrow to the stone beater. However, the feeder plugged when the stone beater wing extensions were extended. The frequency and severity of feeder plugging was greatly reduced when the stone beater extensions were fully retracted. Stone protection was good. Stones larger than 1 in (25 mm) were effectively trapped. Only tiny scratches were evident in the concave and rasp bars after the test. Retracting the stone beater extension did not seem to affect stone trapping.

Threshing was good. Unthreshed losses were low in barley, canola, and flax. However, in wheat, even when using aggressive settings, the unthreshed losses were as high as the free grain loss from the separator and cleaner combined.

Separating was very good. Material flowed smoothly over the separating grates and concave. The discharge beater effectively stripped material from the rotor. Separator loss was typically low in most crops. If desired, the operator could exchange wide and

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

CONTINUED

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narrow separating grates to optimize combine capacity when switching crops.

Cleaning shoe performance was very good. Shoe loss was low in all crops encountered. The sieve opening greatly affected shoe performance. Too large a chaffer opening resulted in higher shoe losses, while too tight a cleaning sieve setting overloaded the tailings. Good sample quality was easily attainable.

Clean grain handling was good. The grain tank filled evenly, and held 173 bu (6.3 m^3) of dry wheat. The unloading auger had ample reach and clearance for all trucks and trailers encountered. A full grain tank of dry wheat unloaded in about 85 seconds. Although the grain stream was compact, some grain was scattered and lost when unloading in windy conditions.

Straw spreading was fair. The chaff was dropped directly onto the ground. Straw was spread evenly up to a maximum of 16 ft (4.9 m). Some long straw built up on the rear axle.

Ease of Operation and Adjustment: Operator comfort was very good. The cab was clean, quiet, and had adequate room for the operator and a passenger. 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 provided rear visibility. The windrow was partially blocked by the steering wheel.

Instrumentation was good. Most important machine and engine components were monitored with a combination of gauges, a digital display, warning lights, and audio alarm. The digital display was shared between engine rpm, rotor rpm, fan rpm, and ground speed. A separate continuous digital display would have been useful. The overhead console contained the alarm module. When an alarm sounded momentarily, the operator usually could not react in time to see the light displayed.

The controls were good. Most of the controls were conveniently located and easy to use. Some of the electrical controls on the right console were not easily identifiable at a glance. Shifting gears was easier when the foot-n-inch pedal was used. The park brake engagement was not self evident.

The loss monitor was good. Both shoe and rotor loss were monitored. The loss monitor gave a reasonable indication of loss when operating at a constant speed. However, when ground speed was varied, the monitor reading was not representative. The operator had to allow some time after forward speed was changed for the reading to stabilize.

Lighting was very good. Short, medium, and long range lighting was very good for the pickup header and could be adjusted to suit wider straight cut headers. The grain tank light was ineffective because of the screen behind the cab window.

Handling was very good. The brakes, hydrostatic lever, and steering were smooth and responsive. 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. The concave was adjusted outside the cab. Rotor speed and fan speed responded slowly.

Ease of setting the components to suit crop conditions was very good. Removing the concave and separator grates was relatively quick, but awkward. Sieve adjustment was made easier with the adjusting tool supplied. Once familiar with the combine's performance, setting was quick, and little fine tuning was required. The straw spreader was easily removed without the aid of hand tools. Checking shoe losses required careful attention.

Ease of unplugging was good. The feeder plugged only in dense, tough windrows. The feeder reverser was effective in backing material from the feeder and table. The rotor seldom plugged; however, when it did, it was easily unplugged by dropping the concave and powering the slug through with the rotor drive in low gear.

Ease of cleaning the combine was fair. The grain tank was open and unrestricted. However, the unloading auger sump was awkward to clean, and retained about 0.8 bu (0.30 m^2). The size and weight of the sieves made removal somewhat difficult.

Ease of lubrication was very good. Daily lubrication was quick and easy.

Ease of performing routine maintenance was very good. 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. The engine power was well matched to combine capacity. Engine power limit and 3% total loss often occurred at the same time. Average fuel consumption was 6.5 gal/h (29.8 L/h), and oil consumption was insignificant.

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

Operator's Manual: The operator's manual was very good. The manual was fairly well organized and clearly written. The manual's size allowed for easy storage; however, the fold out pages were easily damaged.

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

RECOMMENDATIONS:

It is recommended that the manufacturer consider:

1. Modifications to prevent plugging between the pick up belts and stripper bar.
2. Modifications to improve straw spreading.
3. Modifications to make the full grain tank warning less annoying.
4. Providing an optional automatic header height control to be used with pickup headers.
5. Modifications to speed up the rotor and fan speed adjustment response.
6. Modifications to permit safe, convenient sampling of the tailings while harvesting.
7. Modifications to improve the ease of cleaning the unloading auger sump.

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. This recommendation has been noted for future development.
2. An option package for straw/chaff spreading enhancement is now available for the '94 field season.
3. The current sound was chosen to alert with minimal irritation.
4. This will be considered for future models.
5. This recommendation has been noted for future development.
6. This recommendation will be addressed in future models.
7. This recommendation is to be addressed in future development.

GENERAL DESCRIPTION

The Case IH 1666 is a self-propelled combine. It has a single longitudinally mounted rotor, threshing and separating concaves, discharge beater, and a cleaning shoe. The closed tube rotor has three impeller blades and six helical rows of short rasp bars and short separating bars (FIGURE 2). The threshing concaves are of typical bar and wire construction, and the separating grates are stamped steel. Optional square bar grates were also provided. These grates were constructed with radial square bars and longitudinal bars (FIGURE 3). The discharge beater is a three blade wing beater. The cleaning fan is a multi blade, cross flow fan with the blades configured in a chevron pattern. The adjustable lip chaffer and cleaning sieve moved in opposed motion.

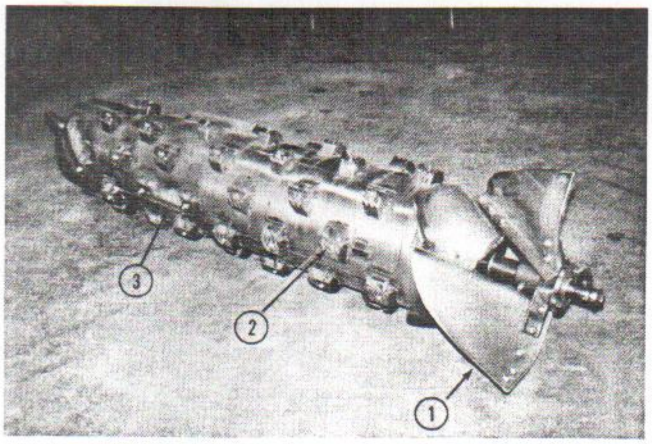

FIGURE 2. (1) Impeller Blades, (2) Rasp Bars, (3) Separating Bars.

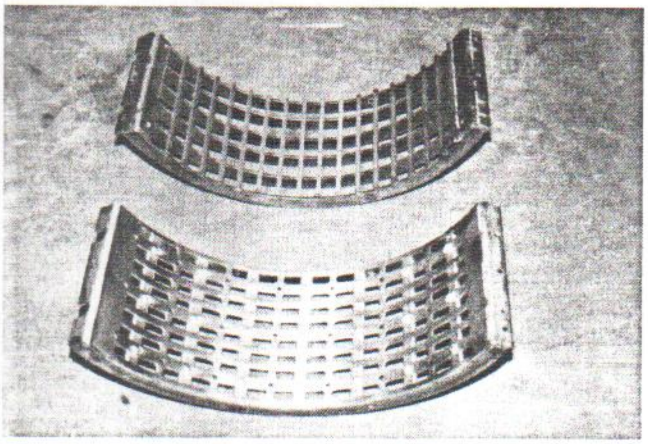

FIGURE 3. Square Bar and Stamped Steel Separating Grates.

Crop is fed to the rotor impeller blades which spiral the material into the rotor. Threshing begins upon first contact with the rotor and continues throughout the length of the threshing concaves. Grain separation occurs throughout the full length of the threshing and separating concaves. The discharge beater strips the processed crop away from the rotor and propels it out the back of the combine. Grain and chaff passing through the concaves fall into conveying augers which deliver the material to the front of the cleaning shoe. The grain is cleaned by a combination of pneumatic and sieving action, and the tailings are returned to the rotor above the third threshing concave (FIGURE 4). The rasp bars and adjustable transport vanes in the top of the rotor cage move the crop rearward.

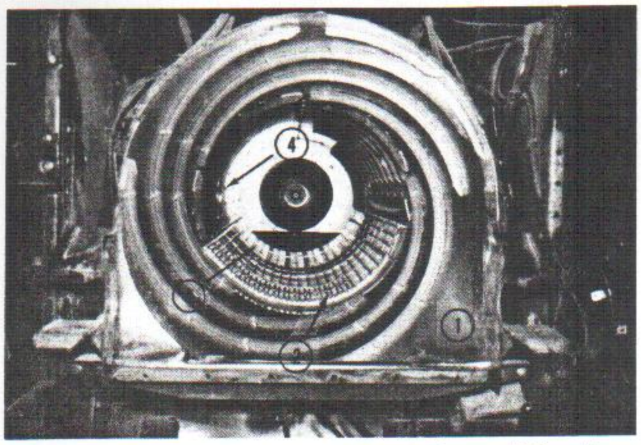

FIGURE 4. Rotor Cage: (1) Transition Cone, (2) Threshing Concave, (3) Separating Grates, (4) Tailing Returns.

The test combine was equipped with a 215 hp (160 kW) turbo charged and intercooled diesel engine, a 13 ft (3.9 m) pickup header, powered rock beater, and optional equipment as listed on Page 2. The Case IH 1666 has a pressurized operator's cab, power steering, hydraulic wheel brakes, and three speed transmission with hydrostatic ground drive.

The separator and header are electrohydraulically engaged. Header height and unloader swing are controlled electrohydraulically, and the unloader is engaged manually. Rotor speed and fan speed are electrically controlled from the cab. The pickup is driven hydraulically and its speed is varied electrohydraulically from the cab. Concave clearance and sieve settings are made externally on the machine. There is no provision to safely and conveniently inspect return tailings while operating. Important component speeds and harvest functions are electronically displayed in the cab.

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 the PAMI test. 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 Case IH 1666. Measurements and observations were made to evaluate the Case IH 1666 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 Case IH 1666 was operated for 107 hours while harvesting approximately 775 ac (314 ha) of various crops. The crops and conditions are shown in TABLES 1 and 2. Capacity tests were conducted in two barley crops, one rapeseed crop, and three wheat crops.

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 "**M**aterial-**O**ther-than-**G**rain". 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".

TABLE 1. Operating Conditions.

Crop	Variety	Yield Range bu/ac	(t/ha)	Cut Width ft	(m)	Sep. Hours	Field Area ac	(ha)	Crop Harvested bu	(t)
Barley	Brier	75-119	(4.0-6.4)	20,26, 42	(6.1,7.9, 12.8)	17.0	103	(42)	10,050	(219)
	Harrington	69-73	(3.7-3.9)	30	(9.1)	5.1	46	(19)	3,265	(71)
	Manley	41-60	(2.2-3.2)	42	(12.8)	3.6	53	(22)	2,410	(53)
Canola	Cyclone	31-37	(1.7-2.1)	24,25	(7.3,7.6)	13.2	108	(44)	3,855	(87)
	Excel	27-39	(1.5-2.2)	20	(6.1)	12.7	91	(37)	2,810	(64)
Rape-seed	Hero	36	(2.0)	24	(7.3)	2.1	17	(7)	630	(14)
Flax	Vimy	28	(1.8)	42	(12.8)	8.0	66	(27)	1,875	(48)
Rye	Prima	48-55	(3.0-3.5)	24	(7.3)	11.0	57	(23)	2,885	(73)
	Puma	21-53	(1.3-3.3)	21,28	(6.4,8.5)	10.3	63	(26)	2,890	(73)
Wheat	Biggar	60	(3.8)	18,25	(5.5,7.6)	4.5	33	(13)	1,994	(54)
	Genesis	29	(1.9)	42	(12.8)	0.7	11	(5)	325	(9)
	Glenlea	35-60	(2.4-4.0)	30	(9.1)	8.8	79	(32)	3,420	(93)
	Katepwa	53	(3.6)	30	(9.1)	1.5	10	(4)	550	(15)
	Makwa	37	(2.5)	25	(7.6)	8.5	38	(15)	1,400	(38)
					Total	107.0	775	(314)	38,359	(911)

TABLE 2. Operation in Stony Conditions.

Field Conditions	Hours	Field Area ac	(ha)
Stone Free	46	913	(127)
Occasional Stones	52	408	(165)
Moderately Stony	8	54	(22)
Total	107	775	(314)

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 Case IH 1666 are summarized in TABLE 3.

TABLE 3. Capacity of the Case IH 1666 at a Total Loss of 3 and 1.5% of Yield.

CROP CONDITIONS

Crop	Variety	Cut Width ft (m)	Crop Yield bu/ac (t/ha)	Moisture Content Straw %	Grain %	MOG/G Ratio	Figure Number
Barley	Manley	42 (12.8)	66 (3.5)	19.6	14.7	0.78	5
Barley	1602	30 (9.1)	60 (3.2)	13.3	14.9	0.69	6
Rape-seed	Hero	25 (7.6)	36 (2.0)	11.0	7.3	1.90	7
Wheat	Biggar	25 (7.6)	56 (3.8)	10.0	14.5	1.08	8
Wheat	Katepwa	30 (9.1)	59 (4.0)	9.4	15.2	1.21	9
Wheat	Laura	30 (9.1)	45 (3.0)	8.9	14.4	1.33	10

CAPACITY AT 3%

Crop	Variety	Feedrates MOG lb/min (t/h)	Grain bu/h (t/h)	Total lb/min (t/h)	Grain Cracks %	Dockage %	Foreign Material %
Barley	Manley	765 (20.8)	1,226(26.7)	1,746(47.5)	0.2	1.3	0.9
Barley	1602	660 (18.0)	1,196(26.0)	1,617(44.0)	0.4	1.4	1.2
Rape-seed	Hero	800 (21.8)	505 (11.5)	1,221(33.2)	0.2	3.0	1.1
Wheat	Biggar	660 (18.0)	611 (16.6)	1,271(34.6)	0.6	2.5	2.5
Wheat	Katepwa	705 (19.2)	583 (15.9)	1,288(35.0)	0.4	1.7	1.6
Wheat	Laura	700 (19.0)	526 (14.3)	1,226(33.4)	0.4	2.5	2.0

CAPACITY AT 1.5%

Crop	Variety	Feedrates MOG lb/min (t/h)	Grain bu/h (t/h)	Total lb/min (t/h)	Grain Cracks %	Dockage %	Foreign Material %
Barley	Manley	720 (19.6)	1,154(25.1)	1,643(44.7)	0.3	1.3	1.0
Barley	1602	520 (14.1)	942 (20.5)	1,274(34.7)	0.4	3.0	2.8
Rape-seed	Hero	800 (21.8)	505 (11.5)	1,221(33.2)	0.2	3.0	1.1
Wheat	Biggar	430 (11.7)	398 (10.8)	828 (22.5)	0.8	2.6	2.5
Wheat	Katepwa	500 (13.6)	413 (11.2)	913 (24.8)	0.5	1.6	1.5
Wheat	Laura	425 (11.6)	320 (8.7)	745 (20.3)	0.8	2.3	1.9

The performance curves for the capacity tests are presented in FIGURES 5 to 10. 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 indicate 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 Manley barley crop used for the test came from a uniform ripe stand. The crop was cut three weeks before the test and had received some rain. Straw moisture was tough while the grain moisture was dry. Grain yield was slightly below average; however, the MOG/G ratio was average. The grain was easy to thresh and straw break up was minimal. The 42 ft (12.8 m) windrow was smooth and uniform and was about 50% wider than the feeder. For this test, wide wire concaves and slotted grates were installed. The channels were removed from the grates.

Engine power limit and 3% total loss were reached at the same time; this occurred at a MOG feedrate of 765 lb/min (20.8 t/h). MOG feedrate at 1.5% total loss was 720 lb/min (19.6 t/h). Rotor loss was the largest component of loss through the full range of feedrates. Rotor loss was low, below 600 lb/min (16.3 t/h) and increased sharply beyond this point. Shoe and unthreshed loss remained low through the full range of feedrates. In this crop, typical operating feedrates would be 650 to 700 lb/min (17.7 to 19.0 t/h).

The 1602 barley crop came from a light stand. The crop was cut two weeks before the test and received a light rain. Grain and straw moisture were in the dry range. The light crop had a typical MOG/G

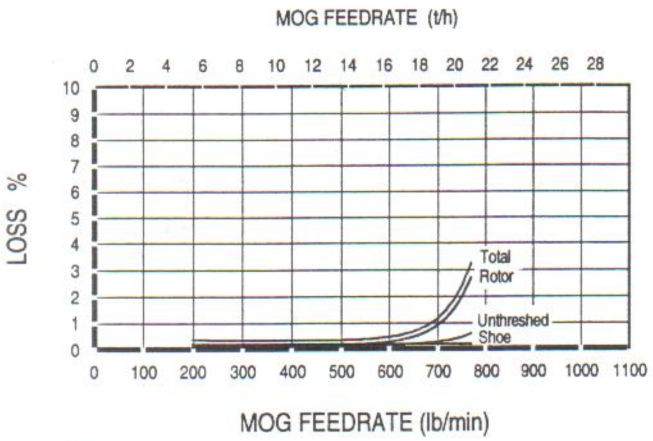

FIGURE 5. Grain Loss in Manley Barley.

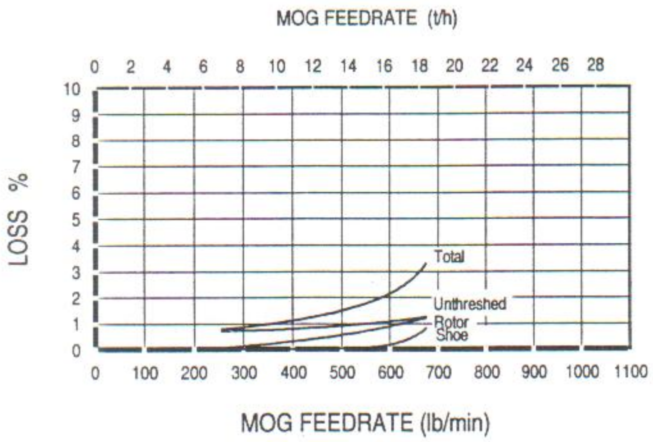

FIGURE 6. Grain Loss in 1602 Barley.

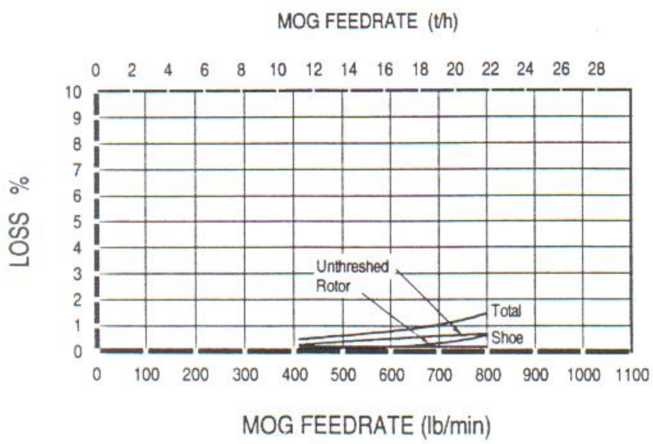

FIGURE 7. Grain Loss in Hero Rapeseed.

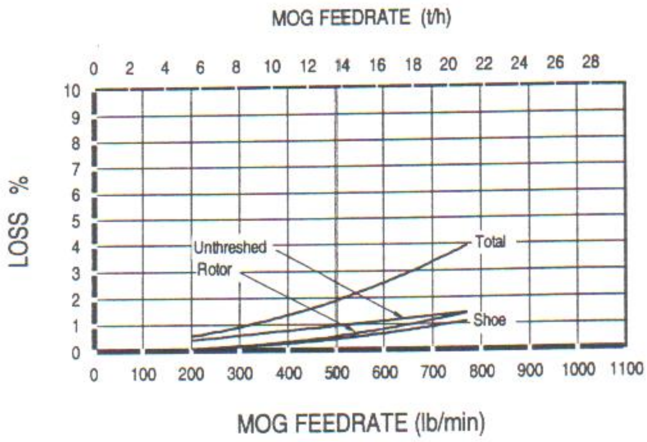

FIGURE 8. Grain Loss in Biggar Wheat.

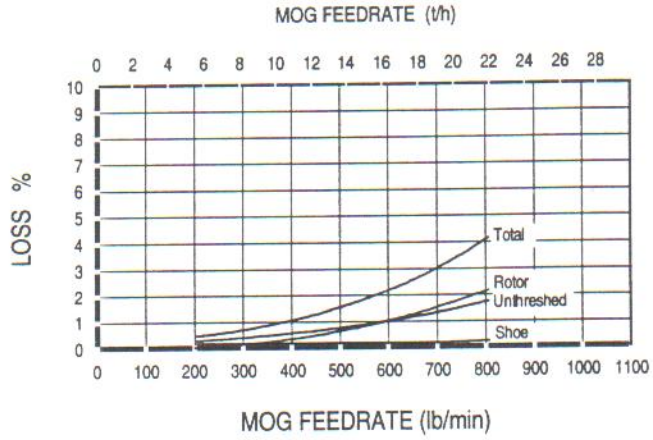

FIGURE 9. Grain Loss in Katepwa Wheat.

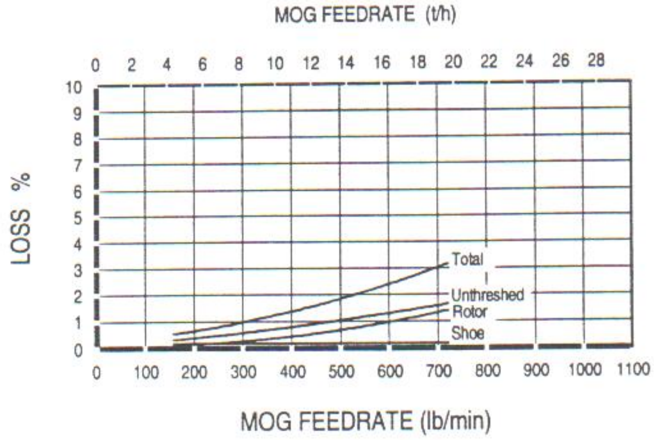

FIGURE 10. Grain Loss in Laura Wheat.

ratio, resulting in a below average grain yield. Threshing and straw break up were typical for this crop. A small amount of wheat was present in this crop. The windrow was light and was slightly wider than the feeder. For this test, the wide wire threshing concaves and square bar separating grates were installed.

Engine power limit and 3% total loss were reached at the same time; this occurred at a MOG feedrate of 660 lb/min (18.0 t/h). The MOG feedrate at 1.5% loss was 520 lb/min (14.1 t/h). At engine power limit, rotor, unthreshed, and shoe loss contributed almost equal amounts to the total loss. Rotor loss was insignificant at low feedrates and increased to just over 1% at engine power limit. Unthreshed loss remained at about 1% over the full range of feedrates. Most of this was due to the wheat intermixed in the crop. Shoe loss remained low to power limit, then increased sharply to just less than 1%. In this crop, typical operating feedrates would be about 600 lb/min (16.3 t/h).

The Hero rapeseed was from a heavy uniform stand. The crop was cut four weeks before the test and received rain and snow. Grain yield was slightly below average; however, the MOG/G ratio was typical. The straw was well cured and had average moisture while grain moisture was slightly below dry. The windrow was fluffy and was twice the width of the feeder. Threshing difficulty was average for rapeseed, and the straw broke up easily. Narrow wire threshing concaves and square bar separating grates were installed for this test.

Maximum feedrate was limited by engine power. This occurred at 800 lb/min (21.8 t/h) at a total loss of 1.5%. Rotor loss was low over the test range of feedrates. Unthreshed loss was low, increasing gradually with feedrate. Shoe loss was insignificant over the full range of feedrates. A typical operating feedrate would be about 600 to 700 lb/min (16.3 to 19.0 t/h) in this crop.

The Biggar wheat was from an average stand. The crop received frost damage that noticeably affected the sample. The crop was cut the same day as the test. Grain yield was slightly below average for Biggar wheat, but the MOG/G ratio was typical. Straw and grain moisture were dry. The windrow was uniform and fluffy with the heads distributed across the windrow. The windrow was 1.5 times the width of the feeder. Threshing was difficult and straw break up was typical. Narrow wire concaves and square bar grates were installed for this test.

The MOG feedrate at 3% total loss was 660 lb/min (18.0 t/h) and 430 lb/min (11.7 t/h) at 1.5% total loss. Rotor, unthreshed and shoe loss started out low and increased gradually as the feedrate increased. At power limit, rotor, unthreshed, and shoe loss were each slightly over 1%. In this crop, typical operating feedrates would be about 550 to 650 lb/min (15.0 to 17.7 t/h).

The Katepwa wheat crop came from a heavy uniform stand. The crop received slight frost damage. The crop was cut a day before the test. The grain yield and MOG/G ratio was above average. Straw moisture was dry while the grain moisture was not quite dry. The large heavy windrow was much wider than the feeder and was somewhat bunchy. Threshing was difficult and the straw was brittle. Narrow wire concaves and square bar grates were installed for this test.

The MOG feedrate at 3% total loss was 705 lb/min (19.2 t/h) and 500 lb/min (13.6 t/h) at 1.5%. Rotor and unthreshed loss were low at the lower feedrates, and increased gradually with an increase in feedrate. Both rotor and unthreshed loss reached about 2% at power limit. Shoe loss was insignificant over the full range of feedrates. Typical operating feedrates would be about 600 to 700 lb/min (16.3 to 19.0 t/h) in this crop.

The Laura wheat crop came from an average, uniform stand. The crop was cut two weeks before the test and received light rain. The grain yield was average while the MOG/G ratio was above average. Straw and grain moisture were dry. The windrow was well laid and smooth. The windrow was slightly wider than the feeder. Threshing was difficult and the straw was typical. Narrow wire threshing concaves and square bar separating grates were used.

Engine power limit and 3% total loss both occurred at a MOG feedrate of 700 lb/min (19.0 t/h). MOG feedrate at 1.5% total loss was 425 lb/min (11.6 t/h). Rotor and unthreshed loss though low at the lower feedrates, increased gradually to about 1.5% each at power limit. Shoe loss was insignificant over the full range of feedrates. Typical operating feedrates would be about 500 to 600 lb/min (13.6 to 16.3 t/h) in this crop.

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.

TABLE 4. Field Workrates.

				Associated Conditions		
Crop	Average Workrate	Grain Feedrate bu/h (t/h)	Area Rate ac/h (ha/h)	Width Of Cut ft (m)	Yield bu/ac (t/ha)	Variety
Barley	High	795 (17.3)	11 (4.3)	42 (12.8)	75 (4.0)	Brier
	Low	513 (11.2)	4 (1.7)	20 (6.1)	119 (6.4)	Brier
	Season	612 (13.3)	8 (3.2)		78 (4.2)	
Canola	High	370 (8.4)	10 (4.0)	25 (7.6)	37 (2.1)	Cyclone
and	Low	177 (4.0)	6 (2.3)	24 (7.3)	31 (1.7)	Cyclone
Rapeseed	Season	261 (5.9)	8 (3.1)		34 (1.9)	
Flax	High	234 (5.9)	8 (3.3)	42 (12.8)	29 (1.8)	Vimy
	Low	234 (5.9)	8 (3.3)	42 (12.8)	29 (1.8)	Vimy
	Season	234 (5.9)	8 (3.3)		29 (1.8)	
Rye	High	322 (8.2)	6 (2.4)	28 (8.5)	53 (3.3)	Puma
	Low	185 (4.7)	9 (3.6)	21 (6.4)	20 (1.3)	Puma
	Season	272 (6.9)	6 (2.3)		48 (3.0)	
Wheat	High	469 (11.9)	8 (3.2)	30 (9.1)	59 (3.7)	Glenlee
	Low	165 (4.2)	5 (1.8)	25 (7.6)	37 (2.3)	Makwa
	Season	322 (8.2)	7 (2.9)		45 (2.8)	

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.

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.

Capacity Compared to Reference II Combine: The capacity of the Case IH 1666 was greater than that of the PAMI Reference II combine in the barley. The Case IH 1666 had 1.5 and 1.6 times the capacity of the Reference II combine respectively in Manley and 1602 barley at 3% total loss. At 3% total loss, the Case IH 1666 had the same capacity of the Reference II in Hero rapeseed. For the Biggar, Katepwa, and Laura wheat crops, the respective capacity of the Case IH 1666 was 1.4, 1.3, and 1.2 times that of the Reference II at 3% total loss.

Compared at 1.5% total loss, the capacity of the Case IH 1666 was 1.7 and 1.9 times that of the Reference II in the Manley and 1602 barley tests. The Case IH 1666 had 1.2 times the capacity the Reference II in Hero rapeseed. In Biggar, Katepwa, and Laura wheat, the Case IH 1666 had respectively 1.0, 1.1, and 0.9 times the Reference II combine.

FIGURES 11 to 16 compare the total losses of both combines over the range of feedrates tested. Each combine's capacity is presented as three lines. The centre line is the actual loss curve, while the lines on each side represent 95% confidence intervals.

QUALITY OF WORK

Picking: Pickup performance was good in most crops.

The pickup was normally operated at about a 30 degree angle to the ground with the gauge wheels adjusted so the teeth just touched the ground. The picking speed was set just slightly faster than ground speed. With these settings, well supported windrows were picked cleanly up to harvesting speeds of 8 mph (12.8 km/h). Picking aggressiveness was increased in poorly supported windrows by increasing pickup speed and reducing the pickup angle. As with many other draper pickups, in extremely hard to pick conditions, where short crop was lying on the ground, some crop was not picked, even at slow ground speeds when using aggressive settings.

In certain crop conditions, such as barley that was tough or short, plugging frequently occurred between the drapers and the pickup stripper. It is recommended that the manufacturer consider modifications to prevent plugging between the pickup belts and stripper bar.

The pickup occasionally picked a few smaller stones when operated in stony conditions.

The wind guard 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 for picking around most corners.

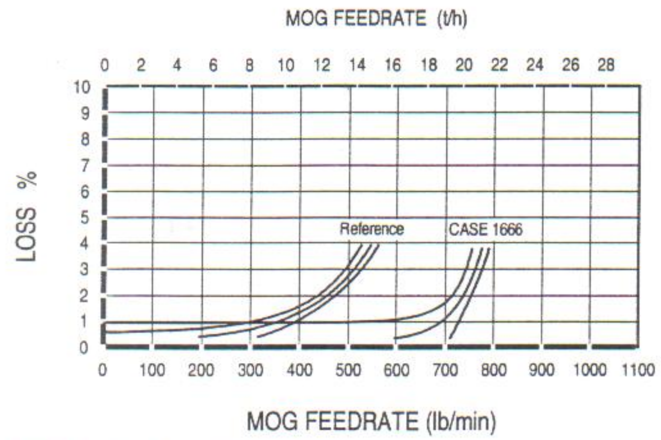

FIGURE 11. Total Grain Loss in Manley Barley.

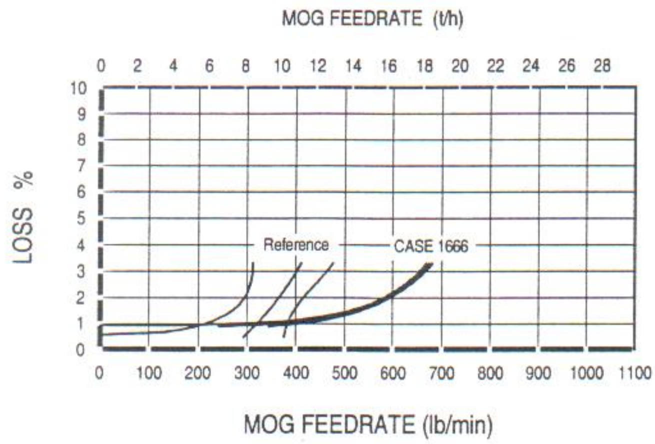

FIGURE 12. Total Grain Loss in 1602 Barley.

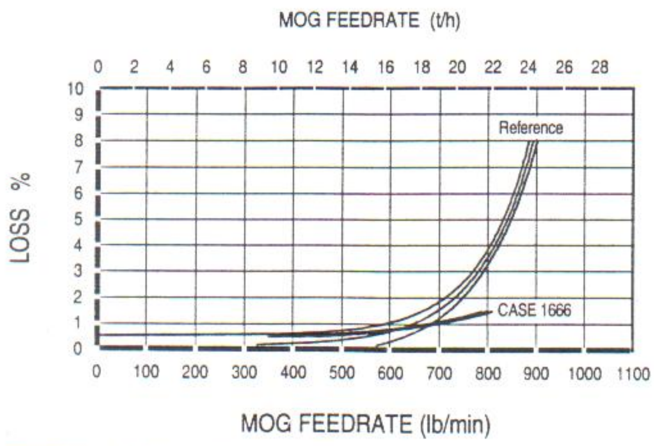

FIGURE 13. Total Grain Loss in Hero Rapeseed.

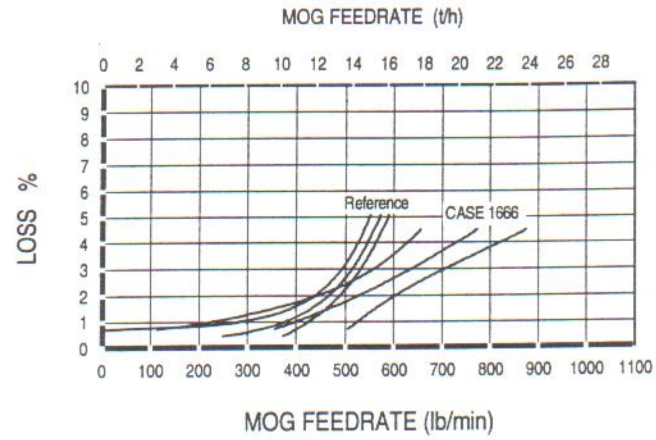

FIGURE 14. Total Grain Loss in Biggar Wheat.

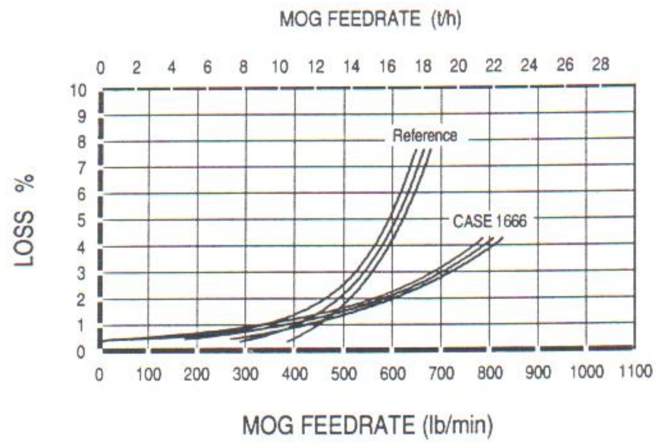

FIGURE 15. Total Grain Loss in Katepwa Wheat.

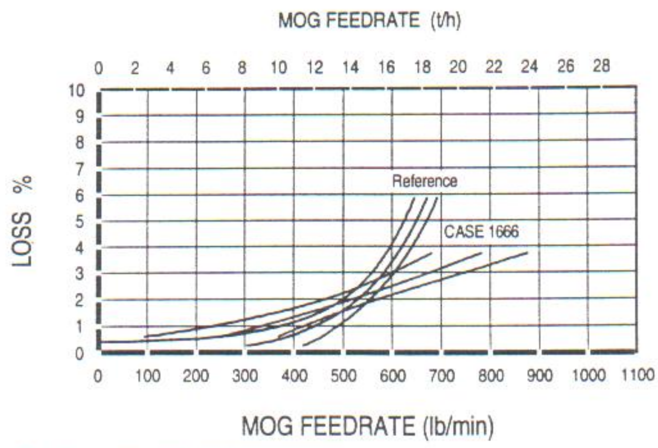

FIGURE 16. Total Grain Loss in Laura Wheat.

Feeding: Feeding was good.

The table auger was aggressive in conveying and feeding crop into the feeder opening. The feed conveyor effectively conveyed material to the stone trap, and the rock beater propelled material into the rotor. However, in tough straw and when operating near power limit, the feed conveyor plugged. The frequency and severity of plugging was reduced by fully retracting the extension blades on the rock beater.

Feeding windrows at the far edges of the table, as when picking around sharp corners, resulted in some crop spiralling around the table auger. This was reduced by decreasing stripper clearances.

Feeding off centre did not noticeably affect feeding or combine performance.

Stone Protection: Stone protection was good.

The stone trap was most effective if emptied regularly to prevent grain and dirt from hardening in the trap. The stone trap collected many stones and roots which the rock beater drove into the sump below the beater. Objects up to 5 in (125 mm) in diameter were often emptied from the trap. Some small stones were heard passing through the rotor. These caused small nicks in the concave and rasp bars.

Threshing: Threshing was good.

Crop flow through the threshing section of the rotor was smooth. The rotor rarely plugged except in large damp windrows. During a plug, the rotor drive was positive causing the engine to stall.

The rotor speeds used resulted in threshing bar velocities that were typical for a conventional combine. Close concave clearances and concave interrupter bars were often used in hard threshing crops such as wheat and flax. Wider concave clearances were used in easier threshing crops such as barley and canola.

The wheat crops encountered in the 1993 season were generally more difficult to thresh than typical. When using maximum rotor speed, minimum clearance, and concave interrupter bars, unthreshed loss often matched rotor free grain loss. This was higher than expected, and may have been due to the specialty rotor. The short rasp bars and helical pattern allowed the unthreshed heads to quickly pass through the rotor without complete threshing. Unthreshed loss could be reduced somewhat by retarding the material flow vanes over the concaves. This increased power requirements. The reduced unthreshed loss often did not justify the reduction in throughput.

TABLE 5 shows the settings PAMI found to be suitable for different crops. Most of the threshing settings PAMI used were more aggressive than those suggested in the operator's manual.

Separating: Separation was very good.

In all crops, material flowed smoothly through the separating area. The rear beater effectively propelled material to the straw spreaders.

Separator loss was typically low in most crops at engine speeds above 2,350 rpm. At lower engine speeds, separator loss was usually greater than 1.5%. Occasionally, damp chaff and barley beards plugged the concave extensions. This, however, had little effect on rotor loss.

In higher yielding and easy to thresh crops, wide wire concaves helped maintain low rotor loss. Rotor loss was also reduced when removing the channels on the slotted separator grate. Rotor loss was further reduced when the slotted grates were replaced by the square bar grates.

The settings used by PAMI are shown in TABLE 5.

Cleaning: Cleaning shoe performance was very good.

With proper setting, shoe loss in the crops encountered was low over the full range of feedrates. The Cross Flow™ fan and long cleaning shoe had much improved cleaning performance over the paddle fan and shorter chaffer of earlier models.

Sieve openings were important for good shoe performance. Without the proper sieve openings, shoe loss and sample quality were greatly affected. Sieve settings of the chaffer (front and middle) and cleaning sieve had to be balanced.

Opening the front of the chaffer beyond 3/8 in (10 mm) resulted in poor air distribution along the edges of the cleaning shoe. Opening the middle chaffer beyond 5/8 in (15 mm) resulted in reduced air flow across the middle of the chaffer. Evidence of excessive opening of either the front or middle chaffer was shoe loss along the left and right side of the shoe.

Closing the cleaning sieve too tight resulted in cleaning sieve blanketing, overloaded returns, and increased shoe loss.

In the cereal crops such as barley, rye, and wheat, the shoe loss was usually low (0.5% or less) over the practical working range. When working near power limit, loss occasionally reached 1%.

In crops that yielded less than 40 bu/ac (2.5 t/ha), the front chaffer was typically set at 3/16 in (5 mm), the middle chaffer at 1/2 in (13 mm), and the cleaning sieve at 1/4 in (6 mm). As the yield increased, the cleaning sieve and middle chaffer were opened slightly. In 100 bu/ac (5.4 t/ha) barley crop, the cleaning sieve was set no less than 3/8 in (10 mm) and the middle chaffer was set no greater than 5/8 in (16 mm).

In the light seed (canola and flax), shoe loss was insignificant. Tighter sieve openings were used in these crops and fan speed was reduced.

The settings used by PAMI are shown in TABLE 5.

The dockage was similar to that of the Reference II combine in all crops.

Clean Grain Handling: Clean grain handling was good.

The open grain tank filled evenly in all crops, although the top corners usually did not fill completely. A full tank held about 173 Imp bu (6.3 m^3) of dry wheat. The full bin sensor activated when the grain tank was about 95% full. The full bin sensor remained on while the feeder was engaged and the sensor covered. The alarm was annoying as it continued while the bin was filling.

The unloading auger had ample reach and clearance for all trucks encountered (FIGURE 17). The unloading auger was hydraulically positioned for unloading to the left and would unload in any position through its full swing range. The auger discharged grain in a compact stream, unloading a full tank of wheat in about 85 seconds. The hydraulic swing, along with the optional long unloading auger, made topping loads or unloading on the go convenient. The high discharge height with the optional long unloading auger fully extended resulted in some grain scattering and loss in moderate winds. The scattering loss could be reduced by unloading with the auger swung partially back to reduce the discharge height.

Straw and Chaff Spreading: Straw spreading was fair.

The bat type spreaders typically spread the straw uniformly from 14 to 16 ft (4.3 to 4.9 m) (FIGURE 18). The spread was narrow compared to the width of cut which was suitable for this combine. The spread width was increased to about 20 ft (6.1 m) by using deeper bats. It is recommended that the manufacturer consider modifications to improve straw spreading.

TABLE 5. Crop Settings.

CROP	ROTOR SPEED (rpm)	CONCAVE SETTING (position #)	SIEVE OPENING								FAN SPEED (rpm)
			FRONT OF CHAFFER		MAIN CHAFFER		TAILINGS		CLEANING		
			in	(mm)	in	(mm)	in	(mm)	in	(mm)	
Barley	850 - 1,000	1 - 2*	1/4	(6)	5/8	(16)	9/16	(14)	3/8	(10)	1,000 - 1,100
Canola	700 - 800	2 - 3**	3/16	(5)	1/2	(13)	11/16	(17)	1/4	(6)	650 - 900
Flax	1,250	0**	3/16	(5)	3/8 - 1/2	(11 - 13)	3/4	(19)	1/4 - 5/16	(6 - 8)	850 - 900
Rye	750 - 1,000	4 - 5**	1/4	(6)	1/2	(13)	5/8	(16)	1/4	(6)	1,000 - 1,100
Wheat	1,000 - 1,150	0 - 1**	3/16 - 1/4	(5 - 6)	1/2	(13)	5/8 - 3/4	(16 - 19)	1/4 - 3/8	(6 - 10)	1,100 - 1,200

* Wide Wire Concave
** Narrow Wire Concave

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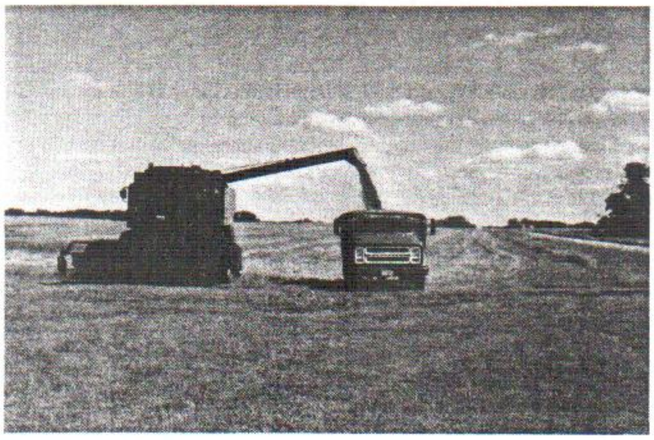

FIGURE 17. Unloading.

FIGURE 18. Typical Straw Spread Pattern.

When operating in long straw and when travelling the same direction as the wind, straw built up on the axles (FIGURE 19). This build up of material was reduced when rubber deflectors were installed on the spreader guards.

FIGURE 19. Material Build Up on Axles.

A small portion of the chaff was spread with the straw.

Removing the spreaders to drop the straw in a windrow took about 2 minutes. Removing a spreader required pulling a pin that secured the spreader to the shaft. Reinstalling the spreader was somewhat more difficult since aligning the hole in the shaft and spreader was slightly awkward for one person.

As with most rotary combines, dry straw dropped in a windrow may not have been suitable for baling with certain types of balers. However, in high straw yielding tough barley, the straw dropped was easy to bale.

An optional spreader kit was provided with the combine. The spreader kit consisted of lowered spreaders, larger diameter spinning discs, and a new slide pan that deflected the chaff into the spreaders. This new spreader kit spread chaff to about 14 ft (4.3 m) and straw to about 18 ft (5.5 m).

EASE OF OPERATION AND ADJUSTMENT

Operator Comfort: Operator comfort was very good.

The Case IH 1666 was equipped with an operator's cab positioned ahead of the grain tank and slightly left of centre.

The cab was easily accessed and had adequate room for the operator and a passenger on the padded storage box lid to the left of the operator. The cab was quiet; however, some feeder chain noise could be heard when the feeder was empty and when dense wads were picked. Incoming air was filtered while fans pressurized the cab to minimize dust leaks. The heater and air conditioner provided comfortable cab temperatures. The seat and steering column provided adequate adjustment.

The operator had a clear view forward and to the sides. The large convex rear-view mirrors provided adequate rear visibility. View of the windrow was slightly obstructed by the steering wheel (FIGURE 20). Visibility of the grain entering the grain tank was restricted by the grain tank screen. The grain level in the grain tank could only be seen through the right cab window when the tank became about 90% full. The unloading auger was visible when swung fully forward, but the operator had to lean forward to see the auger if it was swung back to less than 90 degrees from the combine body.

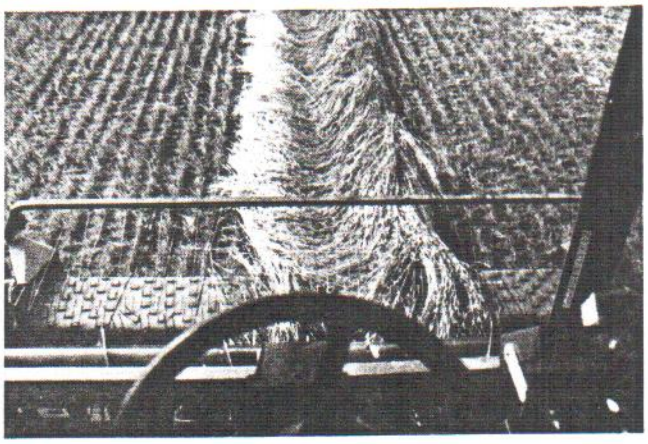

FIGURE 20. Cab View of Windrow.

Instrumentation: Instrumentation was good.

Most of the instruments were located to the right of the operator (FIGURE 21) and in the upper right corner of the cab. The instrument panel to the operator's right contained gauges for engine oil pressure, coolant temperature, battery voltage, fuel level, and engine hours. It also contained an alarm and warning lamps for low engine oil pressure, low coolant level, excessive coolant temperature, alternator malfunction, and parking brake engagement. A digital display selectively showed engine, fan, rotor, and ground speed. A separate continuous readout for engine speed would have been useful.

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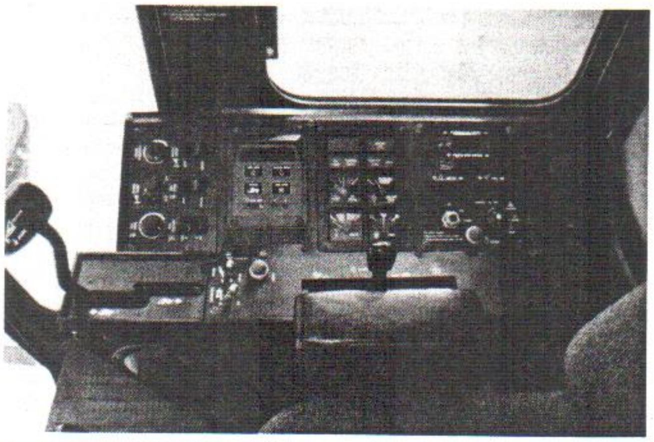

FIGURE 21. Right Control Console.

The instrument panel in the upper right corner had warning lamps and an alarm to signal reduced speed of the clean grain elevator, tailings elevator, cleaning fan, feeder, rotor, rear beater, spreaders, shoe shake, and rotary air screen. The alarm set points for the rotor and fan were adjustable. The warning lamps for shaft speed reductions worked well, but were inconvenient to observe while harvesting. This was annoying when momentary slow downs in shaft speeds occurred. Although the alarm sounded, the warning lamps often did not stay illuminated long enough for the operator to see which alarm had triggered. A flashing warning to show which alarm warning had sounded would have been helpful.

The grain tank alarm activated when the tank was about 95% full and continued until the tank was unloaded. This was annoying. It is recommended that the manufacturer consider modifications to make the full grain tank warning less annoying.

Controls: The Case IH 1666 controls were good.

Most of the controls were located to the right of the operator (FIGURE 21), a few to the left, and the rest on the steering column. Most of the controls were conveniently placed and easy to use. Although clearly marked, they were hard to identify at a glance. A neutral start system prevented the engine from cranking unless the separator switch was shut off and the "foot-n-inch" pedal was depressed. Fuel shut off was integrated into the throttle control lever. The gear shift was located to the left of the operator. Shifting at times was difficult; however, it was made easier if the hydrostatic lever was not in neutral and the "foot-n-inch" pedal was used like a clutch.

The park brake was activated using the left brake pedal and the lock located to the operator's left. Its use was not self evident and the operator had to be familiar with the procedure outlined in the manual. The hydrostatic ground speed lever was conveniently placed and operated smoothly. It had an easy to locate neutral position. The "foot-n-inch" pedal was convenient to use.

The separator and header drives were engaged with toggle switches. These switches were protected from accidental engagement as they had to be lifted before they could be engaged. The feeder reverser control switch worked in conjunction with the feeder drive switch. The header height control switch was located on the propulsion control lever, and was convenient to operate, however, most operators noticed a response lag when raising the header, but not when lowering the header. Although the combine was equipped with an automatic header height system, no provision was made on the pickup header to accommodate the necessary header height sensing components. However, the local Case IH dealer adapted appropriate height sensing hardware and installed these components on the test combine. With these dealer installed components attached, the automatic header height system worked very well, responding smoothly to most ground irregularities. The header could be set to maintain it's height at any position within the normal picking range, and the sensitivity of response was also adjustable. It is recommended that the manufacturer consider providing an optional automatic header height control to be used with pickup headers.

The pickup speed could be either adjusted manually, or set to automatically maintain a set pickup-to-ground speed ratio. The automatic pickup speed control worked well and was very convenient. Rotor speed and fan speed were adjusted with rocker switches. The unloading auger swing control on the steering column was convenient. The unloading auger drive lever was located to the left of the operator and was easy to use.

Loss Monitor: The loss monitor was good.

Two grain loss sensor pads were located at the rear of the rotor and two at the rear of the chaffer sieve. The monitor console was mounted separately from the control console for convenient viewing. A meter display on the monitor console indicated loss from the cleaning shoe, the rotor, or both, relative to acceptable loss observed behind the combine. The monitor console also contained four indicator lights that respectively signalled which sensor pads were being activated. These lights did not indicate the amount of loss.

The monitor was area based using a ground speed signal to regulate loss reading according to the distance travelled in a given time. This should have enabled operating to a fairly consistent loss behind the combine. However, PAMI found that this didn't always happen. Occasionally, an increase in ground speed resulted in a lower meter reading even though loss observed behind the combine had increased. Other times, changes in loss were observed yet the meter had not changed. The reason for the unpredictable response was not apparent, but may have been due to a change in shoe performance or a shift of the loss in relation to the sensors. This was confusing and reinforces PAMI's usual note of caution that meter readings have to be regularly compared to actual losses observed behind the combine.

Lighting: Lighting was very good.

Lighting for night time harvesting was provided by six field lights, a grain tank light, and an unloading auger light. The field lights provided long, medium, and short range forward lighting. The unloading auger light provided rear lighting when the auger was in the retracted position. It also illuminated the auger, side of the truck and grain stream while unloading, regardless of auger position. The effectiveness of the grain tank light was severely reduced by the grain tank screen which restricted the visibility of the grain level. All instruments were well lit, and the road lights were adequate. The two tail lights and four warning lights aided in safe road transport.

Handling: Handling was very good.

The Case IH 1666 was easy to drive and very manoeuvrable. Steering was smooth and responsive at full throttle but became stiff and jerky at low engine speeds. The wheel brakes aided in cornering but were usually not required for picking around most windrow corners. The "foot-n-inch" pedal was helpful when combining bunchy windrows and also aided in shifting the transmission, which otherwise was often difficult to shift. The hydrostatic ground drive was very convenient for matching ground speed to crop conditions. It also made backing up on hard to pick corners quick and easy. The speed ranges in the various gears were appropriate, with most harvesting being done in second 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 travelled well at speeds up to its maximum of 21.4 mph (34.3 km/h), although some bouncing occurred on rough roads.

Adjustment: Ease of adjusting the combine components was good.

Pickup speed, rotor speed, and fan speed were adjusted from the control console, while concave clearance and sieve settings were adjusted externally on the machine.

Table auger finger timing, auger clearance, and auger stripper bar clearance were easily adjusted to suit crop conditions, and once set, did not have to be readjusted.

The rotor speed and fan speed adjustments responded slowly. It is recommended that the manufacturer consider modifications to speed up the rotor and fan speed adjustment response. Concave clearance was easily adjusted from the left side of the machine. The concaves could also be shifted side-to-side with respect to the rotor using draw bolts on the right concave hangers. This was a useful adjustment, but was time consuming and was not frequently changed. The transport vane adjustments were not difficult to make but were generally left in the mid position. Changing the threshing concaves for combining different crops was awkward. Access to the right rear retaining nuts was difficult. The right drive tire was difficult to work around, and the access hole was small and awkward to work through. Once unbolted, the heavy concave sections had to be carefully manoeuvred around the left drive tire and several obstructions. Changing all three threshing concaves took two people approximately 30 minutes. Changing the three separator grates took about 20 minutes.

A sieve adjusting tool provided allowed the operator to quickly adjust the sieves without loosening the wing nuts. Gauging the middle chaffer, tailing and cleaning sieve could be done from the rear; the front chaffer had to be gauged through a left side access door. This was inconvenient.

Field Setting: Field setting was very good.

Once familiar with the specialty rotor and shoe behaviour, optimum settings could usually be determined quickly with little fine tuning required.

Once the straw spreaders were removed, checking combine losses required careful attention since the shoe and rotor discharge were close together. A chopper was not installed in this combine. This allowed the operator to easily assess unthreshed and free grain loss from the rotor. Checking shoe loss required care since a sample had to be caught without catching part of the rotor discharge. Samples caught at the edges of the shoe were less susceptible to rotor loss contamination and easier to obtain. Shoe loss along the edges was usually higher than in the middle.

Threshing was easy to set for in most crops. However, removing white caps in hard to thresh wheat with the specialty rotor required very aggressive settings. These included maximum rotor speed, narrow wire concaves, minimum concave clearance, interrupter bars, and retarding the transport vanes over the concaves. Even with these aggressive settings, unthreshed loss was often difficult to minimize.

The narrow wire concaves were used for most crops. However, installing the wide wire concaves helped produce a good malt barley sample and reduced damage to sensitive, easy to thresh crops.

Increasing threshing aggressiveness also increased separation. Separation was also slightly increased by removing the channels on the slotted grates. Additionally, separation was achieved by installing the square bar separating grates. Narrow wire concaves in conjunction with square bar grates provided good combine performance in most crops. This combination allowed the operator to switch crops without changing concaves or grates.

Setting the shoe for optimum performance required an understanding of the air flow pattern. Setting for the front chaffer sieve and cleaning sieve had a significant effect on shoe performance. This has been explained in the Cleaning section of this report. Increasing or decreasing fan speed by 50 rpm did not have much effect on shoe performance.

The clean grain sample was not convenient to check, but could be reached with a long handled scoop. No provision was made for conveniently sampling the tailings. It is recommended that the manufacturer consider modifications to permit safe, convenient sampling of the return tailings while harvesting.

Unplugging: Unplugging was good.

The table auger, feed conveyor, rotor, and lower tailing auger plugged during the test.

The table auger plugged only when dense, tough wads were picked. These were easily cleared by reversing the feeder. Once cleared, the operator had to occasionally manually remove the large amount of material from the table.

The severity and frequency of feeder plugging was affected by the position of the rock beater wing extensions. When fully extended, the feeder plugged more frequently and was more difficult to unplug. With the beater extensions fully extended, 50% of the plugs could not be freed by the reverser or slug wrench. The operator had to manually pull material from the feeder. This was difficult and time consuming. When the beater wings were fully retracted, the feeder plugged less frequently and the feeder reverser was able to power out the blockage.

The rotor seldom plugged. When plugged, it could usually be cleared by lowering the concave, putting the rotor drive in low gear, and powering the slug through. A slug wrench was provided for rocking the rotor to loosen the obstruction before power up. This was seldom required.

The tailings usually cleared itself once the elevator lower door was opened and the machine engaged momentarily.

Machine Cleaning: Ease of cleaning the Case IH 1666 completely was fair.

Cleaning the grain tank was easy. Very little grain was retained except for about 0.5 bu (18 L) which stayed on top of the sump shields. The grain tank and the auger troughs were easily accessed. However, the unloading auger sump was inconvenient to clean. The sump held about 0.7 to 1 bu (25 to 35 L) of grain and the clean out door did not open fully to provide easy access for cleaning. It is recommended that the manufacturer consider modifications to improve the ease of cleaning the unloading auger sump.

The sieves were slightly awkward to remove due to their weight and size. Once removed, access to the clean grain elevator was good; however, the tailing auger was difficult to get at for cleaning. The shoe supply auger troughs were accessible from the sides and could be cleaned with a vacuum cleaner. Chaff and dust that built up on top of the rotor cage was difficult to remove, unless a portable blower was used. The outside of the combine was easily cleaned.

Lubrication: Ease of lubrication was very good.

Daily lubrication was quick and easy, requiring only about 10 minutes. There were only a few grease points, and most were easily accessed. The combine had sixty-four pressure grease fittings. Five required greasing at 10 hours, nineteen at 50 hours, an additional fifteen at 100 hours, three at 200 hours, eight more at 500 hours, and two yearly. Engine, gear box and hydraulic oil levels required regular checking. Lubrication decals on the sides of the combine greatly aided greasing at the specified intervals, and grease banks were used wherever practical.

The fuel inlet was 8.0 ft (2.4 m) above the ground and was difficult to fill from some gravity fuel tanks.

Changing engine oil and filters was easy.

Maintenance: Ease of performing routine maintenance was very good. Most shields were hinged or easily removed to provide convenient access.

Most belts and chains were easily accessed for lubrication or adjustment. The engine was also easily accessed for inspection and service. Tension of many belts and chains was maintained with spring tensioned idlers. This greatly reduced the time required to check and adjust the drives. The engine air filter restriction indicator warned of primary filter plugging.

Slip clutches protected the feeder conveyor, table auger, both elevators, and the shoe supply augers.

Switching headers or complete header and feeder removal was fairly easy. Rotor removal was somewhat difficult due to the weight of the rotor. Care was required after removing and replacing the front rotor cover. Small gaps at the corners of the cover were sealed with putty during factory assembly to control grain leaks. These had to be checked and resealed each time the cover was removed.

ENGINE AND FUEL CONSUMPTION

The CDC 6T-830 diesel engine started easily and ran well. The engine had adequate power and was well suited for this machine since engine power limit was reached just at about 3% total grain loss in most crops.

Average fuel consumption was 6.5 gal/h (29.8 L/h) based on separator hours, and 4.9 gal/h (22.1 L/h) based on engine hours. Oil consumption was insignificant.

OPERATOR SAFETY

No safety hazards on the Case IH 1666 were apparent. However, normal safety precautions were required and warnings had to be heeded.

The operator's manual emphasized safety. The Case IH 1666 had warning decals to indicate dangerous areas. All moving parts were well shielded, and most shields were easily removed for access.

A neutral start system ensured the separator drive was shut off and the combine would not move before the engine starter would engage.

A header 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 a slow moving vehicle sign, warning lights, signal lights, tail lights, road lights and rear view mirrors to aid safe road transport.

The combine came equipped with a horn to provide the operator with a means to warn individuals outside the machine.

While the safety features were effective, PAMI still emphasizes the importance of conscientious maintenance and operating practices to prevent accident or injury. If the operator must make adjustments or work in dangerous areas, it is important that all switches be disengaged and the 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 very good.

It was fairly well organized and most information was clearly written. The manual was organized into 10 sections and had a table of contents and index. This made finding information convenient. The manual came equipped with fold out pages for schematics. After some use, these pages became damaged. The manual was easy to store because of its small size. However, the information was somewhat compact, and at times the reader had to flip pages to read some instructions completely.

The manual contained sections on safety/decals, instruments/controls, operating instructions, field operation, tires/wheels/spacing/ballast, lubrication/filters/fluids, maintenance/adjustments, electrical system, storage, and specifications. A separate manual provided information on the 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 Case IH 1666 for the 107 hours of operation, during which about 775 ac (314 ha) of crop were harvested.

Table 6. Mechanical History.

ITEM	OPERATING HOURS	EQUIVALENT FIELD AREA ac	(ha)
- Straw spreader idler pulley split and replaced at	33	235	(95)
- Rotary screen brush assembly failed and repaired at	35	247	(100)
- Elevator drive belt failed and replaced at	75	570	(231)
- Damaged sheet metal on clean grain elevator was noticed at	85	638	(258)

Straw Spreader Idler: One half of the straw spreader small idler pulley cracked around the rivets, allowing half the sheave to separate. The bearing on the replacement pulley was dry and squeaked. It was returned for another pulley.

Rotary Screen Brush Assembly: The rivets on the brush assembly coupler failed, and the brush assembly shifted out of position. This allowed the brush assembly to rub against the rotary screen. The rivets were replaced and the brush reinstalled.

Elevator Drive Belt: The elevator drive belt failed when operating in flax. This belt drives the discharge beater and elevators. The cause of the failure was undetermined since the belt failed under normal operating conditions. However, prior to failure, the beater plugged. The separator was not stopped immediately, and the belt slipped over the pulley causing excessive heating.

Clean Grain Elevator Sheet Metal: The tailing elevator drive chain caught the inside sheet metal on the clean grain elevator, slightly damaging it (FIGURE 22). This was caused by excessive slack in the tailing elevator drive chain. A spring loaded idler may have prevented this damage.

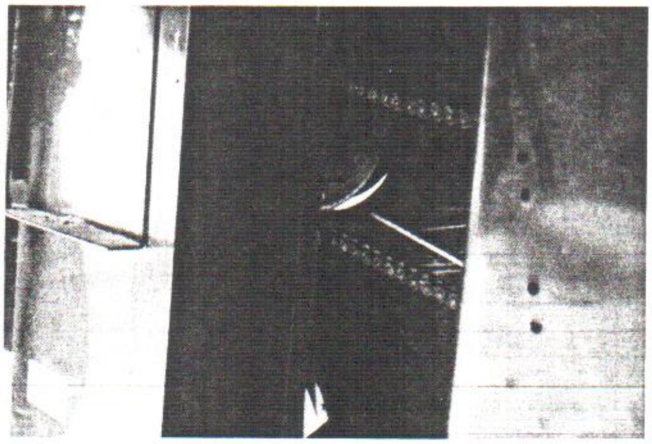

FIGURE 22. Damaged Sheet Metal on Grain Elevator.

APPENDIX I
SPECIFICATIONS

MAKE:	Case IH Self-Propelled Combine
MODEL:	1666
SERIAL NUMBER:	Header - JJC0054637 Body - JJC0104968 Engine - 44808636
MANUFACTURER:	JI Case Company 700 State Street Racine, Wisconsin 53404 U.S.A.

WINDROW PICKUP:

- make	Case IH
- model	1015
- type	rubber draper
- pickup width	12.8 ft (3.9 m)
- number of belts	7
- number of teeth	357
- type of teeth	plastic
- number of rollers	2
- height control	castoring gauge wheels
- speed control	electric over hydraulic
- speed range	0 to 510 ft/min (2.59 m/s)

HEADER:

- type	centre feed
- width	
- table	12.8 ft (3.9 m)
- feeder house	36.0 in (915 mm)
- auger diameter	23.4 in (594 mm)
- feeder conveyor	2 roller chain with C slatted conveyor
- conveyor speed	514 ft/min (2.61 m/s)
- pickup height range	-41.1 to 43.5 in (-1.05 to 1.11 m)
- number of lift cylinders	3
- raising time	adjustable (4.3 s minimum)
- lowering time	adjustable (4.3 s minimum)

STONE PROTECTION:

- type	sump with powered 3 wing beater
- ejection	manually opened access door

ROTOR:

- type	longitudinally mounted, closed tube with 3 intake impeller blades, six rows of helically patterned short rasp bars, 3 short straight separating bars, and 3 angled discharged kickers.
- number of rasp bars	
- threshing	30
- separating	18
- diameter	
- tube	19.4 in (492 mm)
- feeding	32.5 in (825 mm)
- threshing	23.4 in (594 mm)
- separating	23.9 in (606 mm)
- length	
- feeding	20.6 in (524 mm)
- threshing	39.9 in (1,014 mm)
- separating	48.9 in (1,241 mm)
- total	109.4 in (2,779 mm)
- drive	torque sensing variable pitch belt through 2 speed gear box
- speed	
- low range	270 to 660 rpm
- high range	520 to 1,280 rpm

CONCAVE WITH EXTENSIONS (THRESHING):

- number	3
- type	bar & wire
- number of bars	24 for each concave
- configuration	
- narrow space	22 interval with 0.2 in (4.5 mm) wire and 0.24 in (6.4 mm) spacing
- wide space	22 interval with 0.25 in (5.6 mm) wire and 0.6 in (14.3 mm) spacing
- area (3 concaves)	
- concave total	wide - 1339 in^2 (0.86 m^2) narrow - 1339. in^2 (0.86 m^2)
- concave open area	wide - 730 in^2 (0.471 m^2) narrow - 571 in^2 (0.369 m^2)
- open area %	wide - 55% narrow - 43%
- wrap	150 degrees
- option	interrupter bars

SEPARATING AREA:

- number of grates	3
- total area	1137 in^2 (0.735 m^2)
- open area %	
- slotted grates channels)	28% (channels), 38% (no
- square bar grates	56%
- wrap	137 degrees
- separating cage area	772 in^2 (0.498 m^2)
- open area %	39%

THRESHING AND SEPARATING CHAMBER:

- number of spirals	13
- pitch of spirals	adjustable from 11 degrees to 33 degrees, normal position 22 degrees
- grain delivery to shoe	4 auger conveyor

BEATER:

- type	3 wing triangle
- diameter	14.1 in (358 mm)
- speed	860 rpm

SHOE:

- type	opposed action
- speed	280 cpm
- chaffer sieve	
- type	regular tooth
- tooth depth	0.9 in (22 mm)
- louvre spacing	1.3 in (29 mm)
- effective area	
- front	724 in^2 (0.467 m^2)
- middle	1,914 in^2 (1.235 m^2)
- total	2,638 in^2 (1.702 m^2)
- tailings sieve	
- type	regular tooth - adjustable
- tooth depth	0.9 in (22 mm)
- louvre spacing	1.3 in (29 mm)
- effective area	435 in^2 (0.281 m^2)
- chaffer and tailings travel	1.0 in (25 mm) vertical 2.0 in (52 mm) horizontal
- cleaning sieve	
- type	regular tooth - adjustable
- tooth depth	0.9 in (22 mm)
- louvre spacing	1.3 in (29 mm)
- effective area	2,689 in^2 (1.735 m^2)
- cleaning sieve travel	0.7 in (18 mm) vertical 1.2 in (30 mm) horizontal

CLEANING FAN:

- type	cross flow
- diameter	11.5 in (291 mm)
- width	43.2 in (1,098 mm)
- drive	variable pitch electrically controlled
- speed	450 to 1,230 rpm

ELEVATORS:

- type	roller chain with rubber paddles
- clean grain (top drive)	6.0 x 11.1 in (153 x 282 mm)
- returns (top drive)	6.0 x 8.0 in (153 x 202 mm)

GRAIN TANK:

- capacity	173 Imp bu (6.3 m^3)
- unloading time	85 seconds
- unloading auger diameter	12.0 in (300 mm)
- unloading auger length	15.4 ft (4.7 m)

STRAW SPREADER:

- type	double rotating discs, six rubber paddles
- diameter	34.0 in (860 mm)
- speed	280 rpm

ENGINE:

- make	CDC
- model	6T-830
- type	4 stroke turbo charged diesel
- number of cylinders	6
- displacement	505 in^3 (8.3 L)
- governed speed	2,450 rpm
- manufacturer's rating	215 hp (160 kW)
- fuel tank capacity	76.2 gal (347 L)

CLUTCHES:

- header	electro-hydraulic
- separator	electro-hydraulic
- unloading auger	mechanical
NUMBER OF CHAINS:	8
NUMBER OF BELT DRIVES:	10
NUMBER OF GEARBOXES:	3

LUBRICATION POINTS:

- 10 h	5
- 50 h	19
- 100 h	15
- 200 h	3
- 500 h	8
- yearly	2

TIRES:

- front	24.5 - 32
- rear	14.9 - 24

TRACTION DRIVE:

- type	hydrostatic, 3 speed transmission	
- speed range		
- first gear	4.6 mph	(7.3 km/h)
- second gear	8.4 mph	(13.5 km/h)
- third gear	21.4 mph	(34.3 km/h)

OVERALL DIMENSIONS:

- wheel tread (front)	9.0 ft	(2.76 m)
- wheel tread (rear)	9.0 ft	(2.74 m)
- wheel base	11.5 ft	(3.51 m)
- transport height	13.4 ft	(4.08 m)
- transport length	32.2 ft	(9.82 m)
- transport width	16.3 ft	(4.98 m)
- field height	13.4 ft	(4.08 m)
- unloader discharge height	12.9 ft	(3.94 m)
- unloader reach	13.4 ft	(4.10 m)
- unloader clearance	13.3 ft	(4.04 m)
- turning radius		
- left	22.9 ft	(6.98 m)
- right	23.3 ft	(7.09 m)

WEIGHT (GRAIN TANK EMPTY):

- right front wheel	8,105 lb	(3,675 kg)
- left front wheel	9,095 lb	(4,125 kg)
- right rear wheel	2,865 lb	(1,300 kg)
- left rear wheel	2,810 lb	(1,275 kg)
TOTAL	22,875 lb	(10,375 kg)

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PAMI REFERENCE II COMBINE CAPACITY RESULTS

The tables below and FIGURES 23 and 24 present the capacity results for the PAMI Reference II Combine in various barley and wheat crops for 1989 to 1993.

FIGURE 23 shows capacity differences in barley crops for the different years. The 1993 Manley barley crop had slightly below average grain and straw yield. Grain moisture was in the tough range, while straw moisture was typical for windrow conditions. The Reference II had above average capacity in this barley crop.

FIGURE 24 shows the differences in wheat crops. In 1993, the Biggar wheat crop selected had slightly below average grain and straw yield with average straw moisture. Grain moisture was in the tough range. The grain was damaged by frosts, but did not affect grain bushel weight. Wheat capacity in 1993 was slightly below average for the Reference II.

The above average capacity of the Reference II in barley and slightly below average capacity in wheat during the 1993 season indicates that the combines tested alongside the Reference II would also likely have had a similar correlation in capacity. Results show that the Reference II combine is important in determining the effect of crop variable and in comparing results of combines evaluated in different years.

Capacity of the Reference II at a Total Loss of 3 and 1.5% of Yield.

CROP CONDITIONS

Crop	Variety	Cut Width ft (m)	Crop Yield bu/ac (t/ha)	Moisture Content Straw %	Moisture Content Grain %	MOG/G Ratio	Year
Barley	Manley	42 (12.8)	62 (3.3)	22.0	15.6	0.77	1993
Barley	1602	30 (9.1)	60 (3.2)	13.6	14.9	0.68	1993
Rape-seed	Hero	25 (7.6)	27 (1.5)	10.0	7.4	2.08	1993
Wheat	Biggar	25 (7.6)	58 (3.9)	10.0	15.4	1.07	1993
Wheat	Katepwa	30 (9.1)	56 (3.8)	7.8	15.2	1.26	1993
Wheat	Laura	30 (9.1)	40 (2.7)	8.1	14.7	1.32	1993

CAPACITY AT 3%

Crop	Variety	Feedrates MOG lb/min (t/h)	Feedrates Grain bu/h (t/h)	Feedrates Total lb/min (t/h)	Grain Cracks %	Dockage %	Foreign Material %
Barley	Manley	510 (13.9)	828 (18.0)	1,172(31.9)	1.0	1.0	0.2
Barley	1602	420 (11.4)	772 (16.8)	1,038(28.2)	0.7	1.7	0.1
Rape-seed	Hero	780 (21.2)	450 (10.2)	1,155(31.4)	1.5	1.0	1.4
Wheat	Biggar	475 (12.9)	444 (12.1)	919 (25.0)	3.4	3.1	0.5
Wheat	Katepwa	540 (14.7)	429 (11.7)	969 (26.4)	3.2	1.5	0.5
Wheat	Laura	585 (15.9)	443 (12.1)	1,028(28.0)	3.0	2.0	0.5

CAPACITY AT 1.5%

Crop	Variety	Feedrates MOG lb/min (t/h)	Feedrates Grain bu/h (t/h)	Feedrates Total lb/min (t/h)	Grain Cracks %	Dockage %	Foreign Material %
Barley	Manley	415 (11.3)	674 (14.7)	954 (26.0)	1.1	0.9	0.3
Barley	1602	345 (9.4)	634 (13.8)	852 (23.2)	0.7	1.8	0.2
Rape-seed	Hero	695 (18.9)	401 (9.1)	1,029(28.0)	1.5	1.0	1.3
Wheat	Biggar	430 (11.7)	402 (10.9)	832 (22.6)	3.5	2.9	0.6
Wheat	Katepwa	455 (12.4)	361 (9.8)	816 (22.2)	3.5	1.5	0.4
Wheat	Laura	495 (13.5)	375 (10.2)	870 (23.7)	3.4	2.3	0.7

Reference Combine Capacity Results For Previous Years

CROP CONDITIONS

Crop	Variety	Cut Width ft (m)	Crop Yield bu/ac(t/ha)	Moisture Content Straw %	Moisture Content Grain %	MOG/G Ratio	Year
Barley	Heartland	25 (7.7)	92 (4.9)	8.9	10.8	0.81	1990
Barley	Harrington	42 (12.8)	71 (3.8)	9.9	13.4	1.16	1991
Barley	Harrington	30 (9.1)	85 (4.6)	25.0	18.6	1.58	1992
Wheat	Katepwa	30 (9.1)	57 (3.8)	11.5	14.5	0.64	1989
Wheat	Katepwa	42 (12.8)	46 (3.1)	7.7	16.0	1.07	1991
Wheat	Katepwa	60 (18.3)	32 (1.7)	10.4	15.0	1.14	1992

CAPACITY AT 3%

Crop	Variety	Feedrates MOG lb/min (t/h)	Feedrates Grain bu/h (t/h)	Feedrates Total lb/min (t/h)	Grain Cracks %	Dockage %	Foreign Material %
Barley	Heartland	355 (9.7)	700 (15.2)	920 (25.0)	1.6	4.0	3.6
Barley	Harrington	350 (9.5)	580 (12.6)	815 (22.2)	2.1	0.7	0.0
Barley	Harrington	585 (15.9)	460 (10.0)	955 (26.0)	1.2	0.5	0.1
Wheat	Katepwa	405 (11.0)	370 (8.1)	775 (21.1)	2.8	0.5	0.3
Wheat	Katepwa	555 (15.1)	515 (11.2)	1,070(29.1)	2.8	2.3	1.1
Wheat	Katepwa	605 (16.5)	530 (14.4)	1,135(30.9)	2.6	1.4	0.4

CAPACITY AT 1.5%

Crop	Variety	Feedrates MOG lb/min (t/h)	Feedrates Grain bu/h (t/h)	Feedrates Total lb/min (t/h)	Grain Cracks %	Dockage %	Foreign Material %
Barley	Heartland	300 (8.2)	600 (13.1)	755 (20.5)	1.6	4.0	3.6
Barley	Harrington	290 (7.9)	480 (10.5)	675 (18.4)	2.2	0.7	0.0
Barley	Harrington	445 (12.1)	352 (7.7)	725 (19.7)	1.2	0.6	0.1
Wheat	Katepwa	335 (9.1)	305 (6.6)	640 (17.4)	3.5	0.5	0.4
Wheat	Katepwa	470 (12.8)	435 (9.5)	905 (24.6)	3.0	2.3	1.1
Wheat	Katepwa	520 (14.2)	455 (12.4)	975 (26.5)	2.6	1.3	0.5

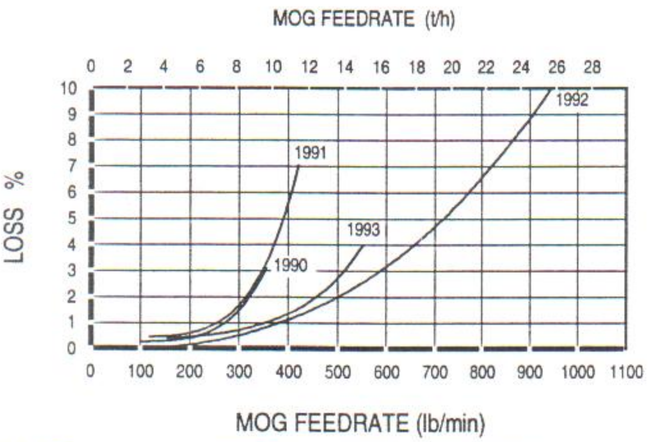

FIGURE 23. Total Grain Loss for the PAMI Reference II Combine in Barley.

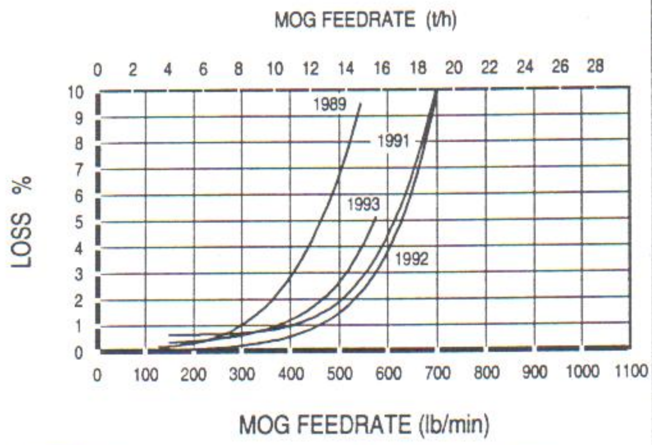

FIGURE 24. Total Grain Loss for the PAMI Reference II Combine in Wheat.

APPENDIX III

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Fair
Very Good	Poor
Good	Unsatisfactory

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SUMMARY CHART

CASE IH 1666 SELF-PROPELLED COMBINE

RETAIL PRICE	$160,190.00 (April, 1993, f.o.b. Humboldt, Saskatchewan)
CAPACITY	
Compared to Reference II	
- barley	1.5 and 1.6 x Reference II
- rapeseed	1.0 x Reference II
- wheat	1.4, 1.3, and 1.2 x Reference II
MOG Feedrates	
- barley - Manley	765 lb/min (20.8 t/h) at 3.0% total loss, FIGURE 5
- barley - 1602	660 lb/min (18.0 t/h) at 3.0% total loss, FIGURE 6
- rapeseed - Hero	800 lb/min (21.8 t/h) at 3.0% total loss, FIGURE 7
- wheat - Biggar	660 lb/min (18.0 t/h) at 3.0% total loss, FIGURE 8
- wheat - Katepwa	705 lb/min (19.2 t/h) at 3.0% total loss, FIGURE 9
- wheat - Laura	700 lb/min (19.0 t/h) at 3.0% total loss, FIGURE 10
QUALITY OF WORK	
Picking	**Good;** usually picked clean, plugged behind drapers in short barley
Feeding	**Good;** smooth crop flow, some feeder plugging with rock beater wings extended
Stone Protection	**Good;** effectively trap stones over 1 in (25 mm) in diameter
Threshing	**Good;** effective threshing, the specialty rotor required aggressive settings for wheat
Separating	**Very Good;** smooth material flow and good range of options to meet various needs
Cleaning	**Very Good;** low loss in all crops, required proper sieve settings
Grain Handling	**Good;** filled evenly, unloaded quickly, some scatter loss in windy conditions
Straw Spreading	**Fair;** straw spread evenly up to 16 ft (4.9 m); chaff was not spread
EASE OF OPERATION AND ADJUSTMENT	
Comfort	**Very Good;** quiet, clean, and comfortable cab, passenger seat
Instruments	**Good;** important functions monitored
Controls	**Good;** conveniently placed and easy to use
Loss Monitor	**Good;** shoe and rotor loss monitored, responded to ground speed and grain loss
Lighting	**Very Good;** forward area well lit
Handling	**Very Good;** brakes, hydrostatic lever, and steering responded smoothly, tight turning radii
Adjustment	**Good;** most adjustments convenient; concave adjusted out of cab
Field Setting	**Very Good;** easy to determine, little fine tuning required
Unplugging	**Good;** feeder reverser worked well with beater extensions retracted
Machine Cleaning	**Fair;** inconvenient to clean grain tank sump, tailings auger, and above rotor cage
Lubrication	**Very Good;** quick, easy, and decals provided interval and location
Maintenance	**Very Good;** most areas easily accessible
ENGINE AND FUEL CONSUMPTION	
Engine	Started quickly, ran well, good match for combine size
Fuel Consumption	6.5 gal/h (29.8 L/h) based on separator hours
OPERATOR SAFETY	Well shielded and many safety features
OPERATOR'S MANUAL	**Very Good;** well organized and easy to find information, easy to store
MECHANICAL HISTORY	A few mechanical problems occurred

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