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Evaluation Report 288

White 9700 Self-Propelled Combine

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

WHITE 9700 SELF-PROPELLED COMBINE

MANUFACTURER:
White Farm Equipment Canada Ltd.
148 Mohawk Street
Brantford, Ontario
N3T 5R7

DISTRIBUTOR:
White Farm Equipment Canada Ltd.
2201 1st Avenue
Regina, Saskatchewan
S4T 3A3

RETAIL PRICE:
$141,130.00 (April, 1982, f.o.b. Humboldt, with 4 m header, 3.7 m belt pickup, straw chopper, 30.5 L x 32 R1 front tires, 16.9 x 24 R3 rear tires, head stone guards, automatic pickup speed control, sidehill package, concave deflector kit, separator deflector kit, second wind board, block heater and radio).

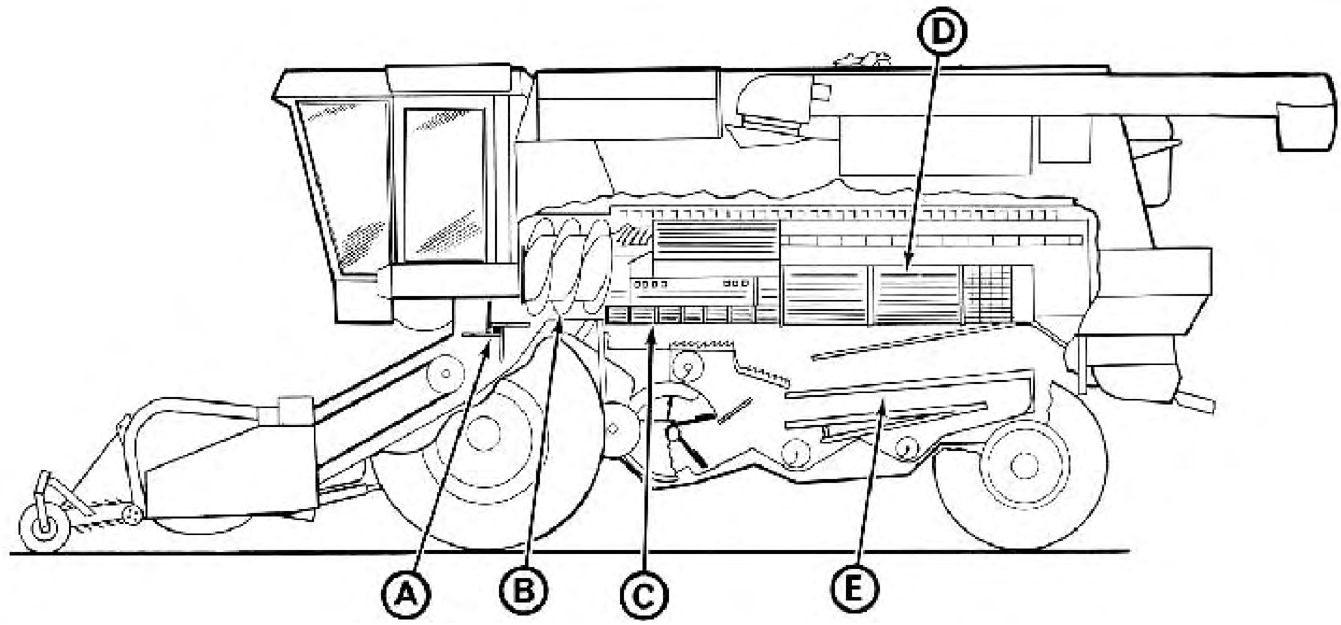


FIGURE 1. White 9700: (A) Feed Impeller, (B) Rotor, (C) Threshing Concaves, (D) Separating Concaves, (E) Shoe.

SUMMARY AND CONCLUSIONS

Functional performance of the White 9700 self-propelled combine was good in dry and tough grain and rapeseed crops.

The MOG feedrate* at 3% total grain loss varied from 9.3 t/h (341 lb/min) in 2.6 t/ha (48 bu/ac) Klages barley to 19.5 t/h (715 lb/min) in 3.3 t/ha (49 bu/ac) Manitou wheat.

For similar total grain loss, capacity of the White 9700 was much greater than the capacity of the Machinery Institute reference combine. Shoe losses limited combine capacity in most crops while rotor and cylinder loss was usually low over the full operating range.

The engine had adequate power for most harvesting conditions. Fuel consumption varied from 30 to 35 L/h (7 to 8 gal/h).

The White 9700 was convenient to operate. Forward and side visibility was very good while rear visibility was restricted. The steering was stiff and the wheel brakes ineffective when turning, which reduced maneuverability in the field; however, maneuverability was adequate for transporting. Lighting for night operation was very good. Most instruments and controls were conveniently placed, easy-to-use and responsive. The air conditioner and heater provided comfortable cab temperatures in all conditions. The cab was relatively dust free. Operator station sound level was about 83dBA.

The White 9700 was fairly easy to set and adjust. Rotor, fan and pickup speeds were adjusted from the cab and concave clearance was adjusted on the machine. The return tailings could not be sampled.

The pickup fed evenly and uniformly in all crops. The table auger plugged occasionally in tough or bunchy windrows. Unplugging the table auger and feeder was difficult and inconvenient. The feed impeller and rotor were aggressive and did not plug during the test. The stone trap stopped most, stones and roots, however, one stone that entered the rotor chamber caused considerable damage. The unloading auger was convenient to position and had ample reach and clearance for unloading on-the-go. Most lubrication points were easy to service. Accessibility was poor for cleaning and fair for service and repair.

The White 9700 was safe to operate as long as the manufacturer's safety instructions were followed. The combine transported well at speeds up to 28 km/h (18 mph).

The operator's manual was well illustrated, clearly written and contained much useful information. Only minor durability problems occurred during the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Improving the rear visibility to the right.
2. Modifications to provide positive separator switch response.
3. Modifications to the rotary screen to prevent radiator plugging.
4. Modifications to improve the ease of steering and to reduce the turning radius.
5. Modifications to improve the ease of operating the stone trap door lever.
6. Modifications to improve uniform straw spreading.
7. Modifications to increase table auger capacity and providing a wrench and hubs to facilitate table auger and feeder conveyor unplugging.
8. Supplying a safe, convenient apparatus to permit sampling the return tailings while harvesting.

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

9. Extending the slot for the front concave hanger to permit adequate travel for setting minimum clearance.
10. Improving the access to the sieve adjusting levers.
11. Modifications to permit full fan speed adjustment from the cab.
12. Modifications to improve the cleaning shoe performance.
13. Modifications to prevent grain leakage past the header drive shaft seals in the grain tank.
14. Supplying locks to hold hinged shields open.
15. Improving the ease of access to the engine compartment ladders and to the grain tank.
16. Revising the suggested chaffer setting for rapeseed.
17. Strengthening the pickup windguard and support assembly.

Senior Engineer -- G. E. Frehlich

Project Technologist -- L. G. Hill

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. The right hand side of new production combines are equipped with a West Coast mirror and convex spot mirror to provide better rear visibility. Additional means to improve rear visibility will be evaluated.
2. Manufacturing techniques have been changed to improve separator switch operation.
3. The rotary radiator screen performance in adverse conditions is being evaluated.
4. The long wheelbase offers several advantages but limits the turning radius. Ways to reduce the turning circle are currently under review. Steering effort has not been reported as a problem by customers.
5. Means to make the stone trap door easier to operate will be investigated.
6. Spreading varies with straw moisture and crop properties. Several ways to provide more even spreading are being evaluated.
7. Increased header auger capacity and easier unplugging will be incorporated in future designs.
8. Alternative remote sampling methods to check tailings are being evaluated.
9. The concave hanger adjustment slot will be extended to provide additional clearance.
10. Sieve adjustment is currently under review.
11. No changes are contemplated at this time.
12. Means to increase cleaning shoe capacity are being evaluated.
13. Sealing improvements have been made.
14. Shield supports will be considered for future designs.
15. Ladder improvements are under review.
16. Machine settings in the operator's manual have been reviewed and changed in the latest printing.
17. Improvements to the windguard will be made on future designs.

MANUFACTURER'S ADDITIONAL COMMENTS

1. A sticking control cable or valve probably caused the header to continue to drop even though the control lever was returned to neutral. This has not been a problem on other machines.
2. On new production machines, the fuel tank filler tube has been increased to 100 mm (4 in) diameter and is accessible from the mounting ladder and walkway.
3. The engine air intake pre-cleaner will be changed to an aspirated pre-cleaner
4. on the next combine production to prevent the problems experienced.
5. "Stiff" steering has not been reported by customers or dealers. We suspect
6. mechanical problems with the machine tested, such as misalignment of the
7. steering column.
8. We suggest the results of the test in Klages barley do not represent the
9. machine capacity since the test was conducted with some questionable combine shoe settings in a field with widely varying crop conditions.

GENERAL DESCRIPTION

The White 9700 is a self-propelled combine with a single longitudinally mounted rotor, threshing and separating concaves, and a cleaning shoe. Threshing occurs mainly at the front section of the rotors while separation of grain from straw occurs throughout the full length of the threshing and separating concaves. The grain is cleaned at the shoe and the return tailings delivered to the front of the rotors. A stone trap is located below the feed impeller.

The test machine was equipped with a 185 kW (248 hp) eight cylinder, turbocharged, diesel engine, a 4 m (13 ft) header, a 3.7 m (144 in) two roller belt pickup, straw chopper and optional equipment listed on page 2.

The White 9700 has a pressurized operator's cab, power steering, hydraulic wheel brakes, and a hydrostatic traction drive. Separator, header and unloading auger drives are electrically engaged. Header height and unloading auger swing are hydraulically controlled. Pickup, rotor and fan speeds are controlled from within the cab while concave clearance and shoe settings are adjusted on the machine. There is no provision to safely and conveniently inspect the return tailings. Important component speeds, and machine and harvest functions are displayed on electronic monitors.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The White 9700 was operated in the conditions shown in TABLES 1 and 2 for 115 hours while harvesting about 460 ha (1135 ac). It was evaluated for ease of operation, ease of adjustment, rate of work, grain loss characteristics, operator safety and suitability of the operator's manual. Throughout the test, comparisons were made to the Machinery Institute reference combine.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield t/ha	Swath Width m	Hours	Field Area ha
Barley	Betzes	2.3	7.6	2.0	6
Barley	Bonanza	3.1	6.1 to 7.6	8.5	32
Barley	Elrose	2.7	6.7 to 7.3	2.5	10
Barley	Klages	2.8	7.3 to 7.6	5.0	13
Rapeseed	Altex	1.8	5.5 to 6.1	9.5	36
Rapeseed	Candle	1.4	7.3 to 7.6	9.0	30
Rapeseed	Regent	1.4	6.1	17.5	62
Rye	Frontier	2.5	6.1	7.0	24
Rye	Puma	2.2	5.5 to 9.1	6.0	26
Wheat	Canthatch	2.1	7.3 to 12.2	2.0	9
Wheat	Manitou	2.6	7.5	22.0	95
Wheat	Neepawa	2.3	6.1, 7.3 & 8.5	21.0	100
Wheat	Park	3.0	7.3	3.0	17
Total				115	460

TABLE 2. Operation in Stony Fields

Field Condition	Hours	Field Area (ha)
Stone Free	33	154
Occasional Stones	73	271
Moderately Stony	9	35
Total	115	460

RESULTS AND DISCUSSION

EASE OF OPERATION

Operator Location: The White 9700 was equipped with an operator's cab as standard equipment. The cab was positioned ahead of the grain tank and slightly left-of-center. Forward and side visibility was very good while rear visibility was restricted. The rear view mirrors improved rear visibility to the left but only slightly improved rear visibility to the right. It is recommended that the manufacturer consider improving rear visibility to the right. Header visibility was very good for most operators when leaning slightly to the right (FIGURE 2). The grain level was visible through the rear window until the tank was nearly full.

The seat was comfortable and could be adjusted to suit most operators. The steering column was adjustable, but the steering wheel angle was uncomfortable for some operators. Incoming air was effectively filtered while the fans pressurized the cab to reduce dust leaks. The air conditioner and heater provided suitable cab temperatures. Operator station sound level was about 83 dBA.

Controls: The control arrangement is shown in FIGURE 3. Most

controls were conveniently located and easy to use. However, the separator switch frequently failed to disengage the separator and it is recommended that the manufacturer consider modifications to provide positive separator switch response.
The rotor speed adjustment responded very quickly, making it inconvenient to obtain small speed changes.

(A)

(B)
FIGURE 2. View of Incoming Windrow (A) Normal Seated Position, (B) Leaning to the Right.

The header lift response was suitable for most conditions, however, the header frequently continued to drop even though the control lever had returned to neutral.

The pickup speed was varied either manually with a switch or by the automatic speed control. Both systems were very responsive and convenient.

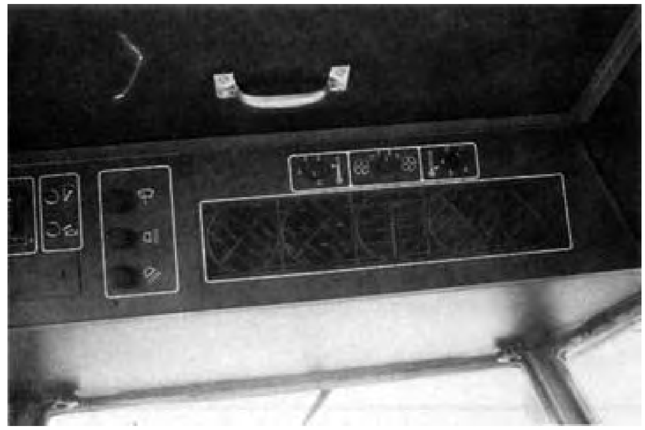
Instruments: The right instrument console (FIGURE 3B) contained gauges, warning lights, a digital readout and a grain loss monitor. The gauges indicated engine hour, oil pressure and coolant temperature. The warning lights and audio alarm indicated low fuel level, reduced battery voltage, excessive coolant temperature, low engine oil pressure, low coolant level, restricted air filter, parking brake engagement, full grain tank and a speed reduction of major combine drives. The digital readout selectively displayed engine, ground, cleaning fan and rotor speeds, fuel remaining and battery voltage.

All the instruments worked well and were clearly visible and conveniently located.

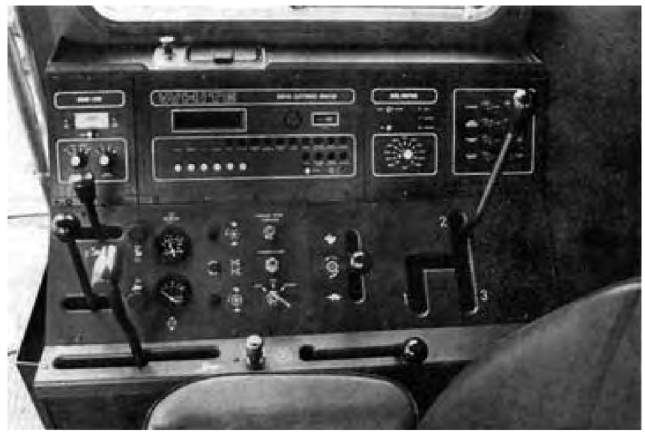
Loss Monitor: Two loss monitor sensors were located behind the chaffer and one behind the rotor. The loss monitor indicated changes in mechanical shoe loss but was ineffective in detecting airborne shoe loss. Rotor loss was usually low. The monitor reading was meaningful only if it was compared to actual loss and if the response was set for each crop condition.

Lights: Lighting for night harvesting was very good. There were seven front lights, a grain tank light and an unloading auger light. The warning and tail lights were adequate for safe road travel. Control and instrumentation lighting were good.

Engine: The engine started easily and ran well. It had adequate power for operating in most conditions.



(A)



(B)

(C)
FIGURE 3. Instruments and Controls (A) Upper Console (B) Right Console (C) Left Console.

Average fuel consumption varied from 30 to 35 L/h (7 to 8 gal/h). Oil consumption was insignificant. The fuel tank could be filled from average height gravity fuel tanks although access to the fuel tank was inconvenient.

The radiator frequently plugged when operating in thistle infested crops (FIGURE 4) as thistle down readily passed through the end of the rotary screen. It is recommended that the manufacturer consider modifications to the rotary screen to prevent radiator plugging.

The engine air intake used a centrifugal pre-cleaner and two dry filter elements. Under severe conditions the centrifugal pre-cleaner inlet screen plugged occasionally. The outer dry filter element required periodic cleaning.

Maneuverability: The White 9700 was difficult to manoeuvre in the field. The steering was stiff and the wheel brakes were ineffective when turning. The turning radius was about 8 m (26 ft), which made it impossible to pick around many corners. The hydrostatic drive made backing up easy on these corners. It is recommended that the manufacturer consider modifications to improve the ease of steering and reduce the turning radius.

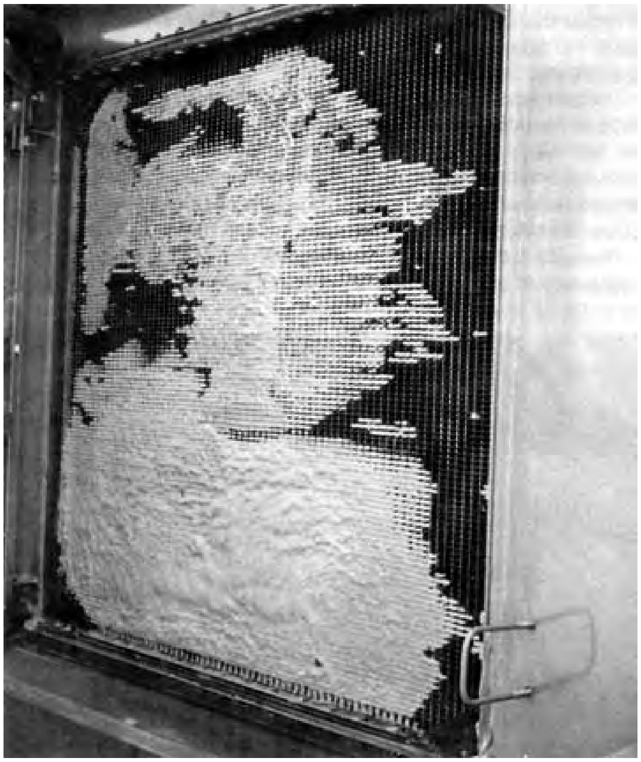


FIGURE 4. Radiator Plugged with Thistle Down.

Stability: The White 9700 was very stable in the field even with a full grain tank. Normal caution was required on hillsides. The combine transported well at speeds up to 28 km/h (18 mph).

Grain Tank: The volume of the grain tank was 9.4 m³ (260 bu). The tank filled evenly and completely in all crops. The grain level could be observed through the rear window until the tank was nearly full. A warning light and audio alarm signalled a full grain tank.

Unloading a full tank of dry wheat took about 155 seconds. The unloading auger had ample reach and clearance for unloading on-the-go (FIGURE 5).

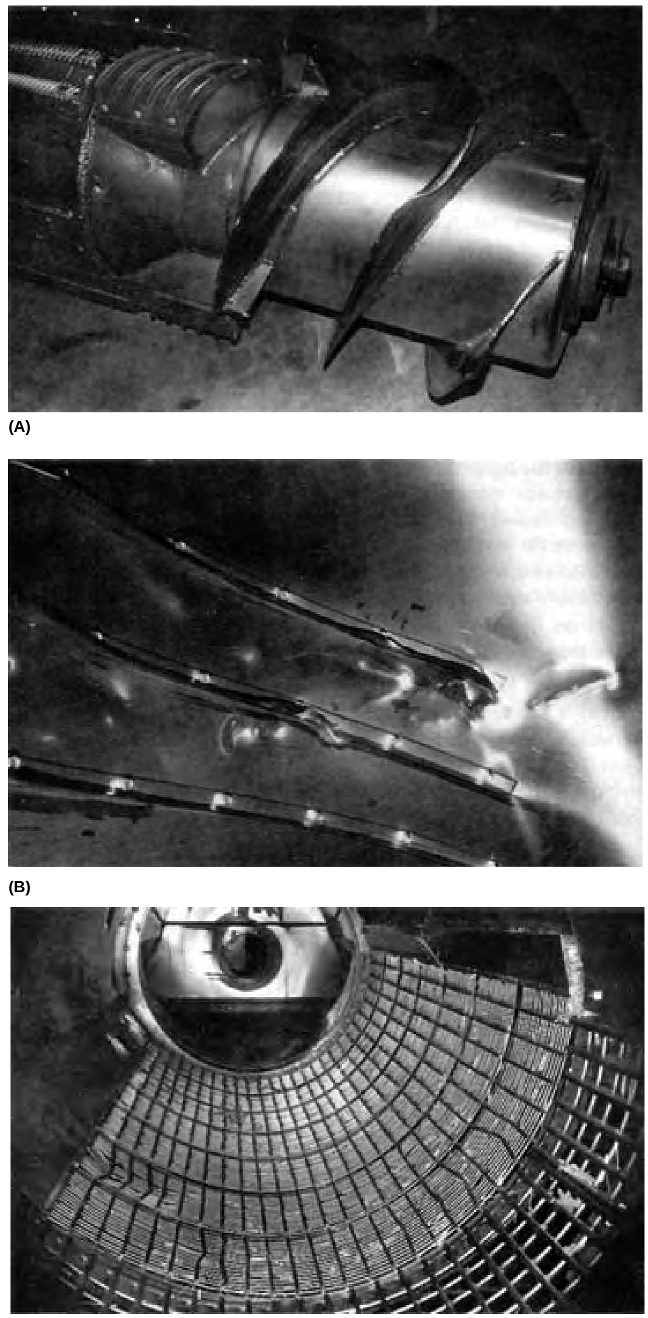
FIGURE 5. Unloading.

Pickup: The White 9700 was equipped with a 3660 mm (144 in) White 600, two roller, draper pickup with Rilsan pickup teeth and a windguard. Picking height was controlled by castor wheel adjustment while picking angle was determined by the support chains and header height. The pickup was hydrostatically driven and pickup speed could be controlled manually or automatically from the cab. The optional automatic pickup speed control worked very well and automatically changed pickup speed as ground speed changed.

The pickup performed well in most crops at speeds up to 11 km/h (7 mph). At high ground speeds the pickup had to be operated parallel to the ground. In rapeseed, the windguard had to be removed to prevent bunching and excessive shelling.

Stone Protection: The White 9700 was equipped with a stone trap (FIGURE 6), located below the feed impeller that prevented most stones and roots from entering the rotor chamber. One stone that entered the rotor chamber damaged the rotor intake flighting, turning vanes and threshing concaves (FIGURE 7). The stone trap lever was inconvenient to reach and difficult to latch. It is recommended that the manufacturer consider modifications to improve the ease of operating the stone trap door lever.

FIGURE 6. Stone Trap.



(A)

(B)

(C)

FIGURE 7. Stone Damage: (A) Intake Flighting, (B) Turning Vanes and (C) Concaves.

Straw Chopper: The optional straw chopper attachment performed well in most crops. The straw chopper spread crop up to 5.5 m (18 ft). The spread pattern was uneven with more material being distributed to the left (FIGURE 8). Removing the second deflector fin from the left end of the straw chopper tail plate improved the spread pattern. However, it is recommended that the manufacturer consider modifications to provide more uniform straw spreading.

FIGURE 8. Uneven Straw Distribution.

The straw chopper had to be removed to permit windrowing. Removal and installation of the straw chopper was difficult as it was heavy and awkward to handle. As is common with rotary combines the straw was generally less suitable for baling than straw from a conventional combine.

Plugging: The table auger plugged frequently and the feeder conveyor plugged occasionally in bunchy and tough windrows, especially rapeseed. Raising the table auger reduced plugging but permitted material to build up at the outer ends of the pickup stripper bar. Unplugging the table auger and feeder conveyor was inconvenient and difficult as they could not easily be reversed. It is recommended that the manufacturer consider modifications to increase table auger capacity and providing a wrench and hubs to facilitate table auger and feeder conveyor unplugging.

The rotor feeder impeller and rotor were very aggressive and did not plug during the test.

Machine Cleaning: Cleaning the White 9700 for combining seed grain was laborious and time consuming. The sloping center section and many support braces made working in the grain tank very difficult. The unloading auger sump retained a considerable amount of grain and the bottom cross auger was inaccessible. The grain pans under the concaves were difficult to clean. Two people were required to remove the chaffer and sieve to obtain access to the clean grain cross auger; the tailings cross auger was not easily accessible. Build-up of dust and chaff on top of the rotor cage was very difficult to remove. The exterior of the combine was easily cleaned.

Lubrication and Service: The White 9700 had thirty-four pressure grease fittings. Fourteen needed greasing every 10 hours, sixteen every 50 hours, and four every 500 hours. Most lubrication points were easily accessible. Engine, gear boxes and hydraulic oil levels required regular checking. Most routine servicing and adjustments were easily made. However, tightening the clean grain elevator chain was inconvenient and time consuming.

EASE OF ADJUSTMENT

Field Adjustment: The White 9700 was fairly easy to adjust and could be set by one person. Rotor and fan speed were varied from the cab while concave clearance, chaffer and sieve openings, wind board position, and concave and separator deflector position were set on the combine.

The return tailings could not be conveniently inspected. A method of sampling return tailings would be beneficial in setting the combine. It is recommended that the manufacturer consider supplying a safe convenient apparatus to permit sampling the return tailings while harvesting.

Concave Adjustment: The combine was equipped with an adjustable threshing concave and a stationary separating concave (FIGURE 9). The small grain threshing concaves used throughout the tests were accessible through one side door and two doors in the grain tank. The separating concaves were accessible through doors on each side.

FIGURE 9. Threshing and Separating Concaves.

Initial levelling and adjusting of the threshing concaves was easy, however, access for checking concave clearance was inconvenient. The concave could be levelled by adjusting the front or rear concave hanger bolts. The concave was initially set to obtain 1 to 2 mm (0.04 and 0.07 in) clearance between the highest rasp bar and the bottom of the third and rear concaves with the clearance indicator set at zero. The front hanger slot had to be extended to obtain adequate travel for initial concave setting (FIGURE 10). It is recommended that the manufacturer consider extending the slot for the front concave hanger to permit adequate travel for setting minimum clearance.

Once the concaves were initially set, clearance could be varied from 1 to 50 mm (0.04 to 2.0 in) using the ratchet lever located on the left side of the combine.

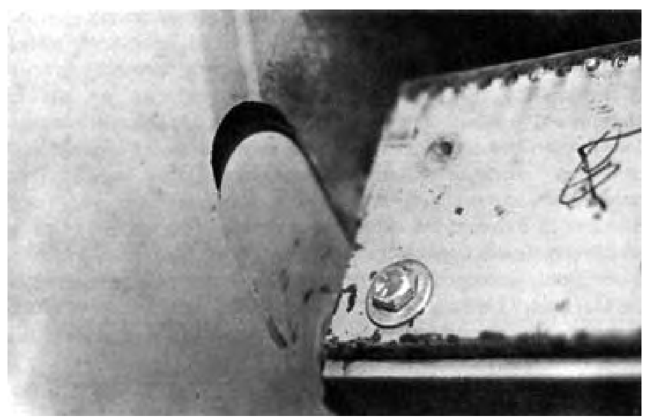


FIGURE 10. Extension of Hanger Slot.

Suitable concave indicator settings for harvesting were 0 to 0.25 in hard-to-thresh wheat, 0 to 0.50 in barley and 0.50 to 1.25 in fall rye and rapeseed. In hard threshing crops concave clearance was reduced to get maximum threshing and separation while in easier threshing crops clearance was increased to reduce straw break-up and shoe loading.

Removing the concaves or installing the concave cover plates required two people and was inconvenient and time consuming.

Rotor Adjustment: The rotor (FIGURE 11) was powered through a two speed gearbox and a hydraulically controlled variable speed belt drive. The high speed range was used throughout the test. It provided rotor speeds from 400 to 900 rpm with the actuator limiter removed.

Suitable rotor speeds were 800 to 900 rpm in wheat, 700 to 800 rpm in fall rye, 650 to 800 rpm in barley and 450 to 600 rpm in rapeseed.

Shoe Adjustment: The chaffer was easy to adjust but the sieve adjustment was inconvenient. Three wing nuts had to be loosened and a flap removed to permit access to the sieve adjusting lever. It is recommended that the manufacturer consider improving the access to the sieve adjusting lever. Fan speed could be varied from within the cab over a limited speed range. To extend the speed range the fan drive belt had to be moved to a different drive sheave and the idlers and actuator repositioned (FIGURE 12). This procedure was inconvenient and time consuming. It is recommended that the manufacturer consider modifications to permit full speed adjustment from the cab. The two wind boards were usually set to direct air to the front of the chaffer and sieve.

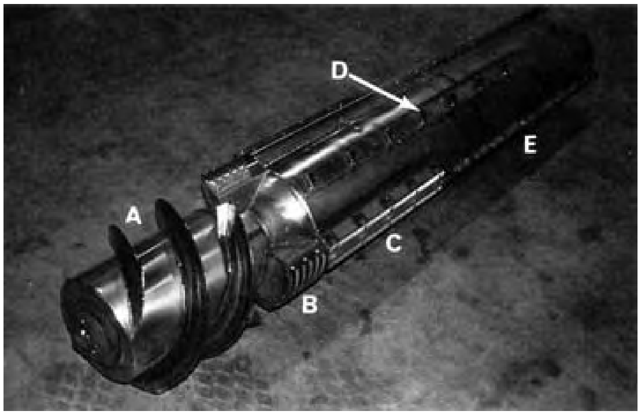


FIGURE 11. Rotors: (A) Intake Flighting, (B) Threshing Elements, (C) Threshing Bars, (D) Impeller Blades, (E) Separating Fins.

FIGURE 12. Fan Drive.

Deflector Adjustment: The White 9700 was equipped with the optional concave and separator deflector kits. The deflectors were located along the right side of the threshing concave and both sides of the separating concave. Threaded rods with wing nuts were used to position the deflectors.

The deflectors were adjusted for each crop condition to provide uniform distribution of material onto the shoe. The distribution of material on the shoe was checked by “kill-stalling” the combine while under load (to prevent damage to the turbo-charger the separator should be disengaged and the engine restarted immediately). For most crops the deflectors were set to deflect the material away from the side and in some crop conditions the front left deflector had to be set against the concave. Proper adjustment of the deflectors significantly improved shoe performance.

Header Adjustment: The White 9700 was tested only with a windrow pickup attachment. The header table or the complete header and feeder assembly could be easily removed by one man in 10 minutes. A header support jack was provided.

Adjustments were provided for header levelling, feeder chain tension, limiting the front feeder drum travel, table auger clearance, and auger finger timing.

Slip Clutches: Slip clutches protected the table auger and feeder conveyor.

RATE OF WORK

Average Workrates: TABLE 3 presents average workrates for the White 9700 in all crops harvested during the test. As average workrates are affected by crop condition, windrow quality, field conditions, and availability of grain handling equipment they should not be used to compare combines tested in different years. Average workrates varied from 4.7 t/h (207 bu/h) in 1.4 t/ha (25 bu/ac) Candle rapeseed to 17.0 t/h (623 bu/h) in 3.0 t/h (44 bu/ac) Park wheat.

TABLE 3. Average Workrates.

Crop	Variety	Average Yield t/ha	Average Speed km/h	Average Workrate	
				ha/h	t/h
Barley	Betzes	2.3	4.0	3.0	6.9
Barley	Bonanza	3.1	6.2 & 5.0	3.8	11.8
Barley	Elrose	2.7	6.0 & 5.3	4.0	10.8
Barley	Klages	2.8	3.6 & 3.4	2.6	7.3
Rapeseed	Altex	1.8	6.9 & 6.2	3.8	6.8
Rapeseed	Candle	1.4	4.5 & 4.3	3.3	4.7
Rapeseed	Regent	1.4	5.7	3.5	5.0
Rye	Frontier	2.5	5.8	3.4	8.6
Rye	Puma	2.2	7.8 & 4.7	4.3	9.5
Wheat	Canthatch	2.1	6.2 & 3.7	4.5	9.5
Wheat	Manitou	2.6	5.7	4.3	11.2
Wheat	Neepawa	2.3	7.9, 6.6 & 5.6	4.8	11.0
Wheat	Park	3.0	7.6	5.7	17.0

Maximum Feedrate: The workrates in TABLE 3 represent average workrates at acceptable loss levels. In most crops much higher feedrates could be attained when operating at the engine power limit. The maximum acceptable feedrate was limited by grain loss while the maximum feedrate was limited by engine power in heavy crops and by pickup performance in light crops. Throughput was only slightly reduced in tough crops.

Capacity: Combine capacity is the maximum rate at which a combine, adjusted for optimum performance can harvest a crop at a specified total loss level. Many crop variables effect combine capacity. Crop type and variety, grain and straw yield and moisture content, local climatic conditions and windrow quality can cause capacity variations.

MOG Feedrate, MOG/G Ratio and Percent Loss: When determining combine capacity, combine performance and crop conditions must be expressed in a meaningful way. The loss characteristics of a combine depend mainly on two factors, the quantity of the straw and chaff being processed and the quantity of grain being processed. The mass of straw and chaff passing through a combine per unit time is called MOG Feedrate. MOG is an abbreviation for “Material-Other-than-Grain” and represents the mass of all plant material passing through the combine except for the grain or seed.

The mass of grain or seed passing through the combine per unit time is called Grain Feedrate. The ratio of MOG Feedrate to the Grain Feedrate, abbreviated as MOG/G, indicates how difficult a crop is to separate. For example, if a combine is used in two wheat fields of identical yield, one with long straw and one with short straw, the combine will have better separation ability in the short crop and will be able to operate faster. This crop variable is expressed as the MOG/G ratio. MOG/G ratios for prairie wheat crops vary from about 0.5 to 1.5.

Grain losses from the combine are of two main types, unthreshed grain still in the head and threshed grain, which is discharged with the straw and chaff. Unthreshed grain is called cylinder loss. Free grain in the straw and chaff is called separator loss and consists of shoe and walker (or rotor) loss. Losses are expressed as a percent of total grain passing through the combine.

Combine capacity is expressed as the maximum MOG Feedrate at which total grain loss (cylinder loss plus separator loss) is 3% of the total grain yield.

Capacity of the White 9700: TABLE 4 presents capacity for the White 9700 in five different crops. MOG Feedrates for a 3% total grain loss varied from 9.3 t/h (341 lb/min) in 2.6 t/ha (48 bu/ac) Klages barley to 19.5 t/h (715 lb/min) in 3.3 t/ha (49 bu/ac) Manitou wheat.

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics for the White 9700 in the five crops described in TABLE 4 are presented in FIGURES 13 to 17.

Rotor Loss: In most crops rotor loss was low over the entire operating range and did not limit combine capacity.

Shoe Loss: Shoe loss usually limited combine capacity. Shoe performance was greatly reduced by uneven material distribution and air flow. The concave and separator deflectors helped to uniformly distribute the material to the shoe, but the grain was frequently concentrated on one side and chaff on the other. It was also difficult

TABLE 4. Capacity at Total Loss of 3% of Yield

Crop Conditions							Capacity Results			
				Grain Moisture						
Crop	Variety	Width of Cut m	Crop Yield t/ha	Straw %	Grain %	MOG/G	MOG Feedrate t/h	Grain Feedrate t/h	Ground Speed km/h	Loss Curve
Barley	Bonanza	7.4	2.9	6.1	12.0	0.73	14.6	20.0	9.5	Fig. 13
Barley	Klages	7.3	2.6	7.6	11.4	0.94	9.3	9.9	5.2	Fig. 14
Wheat	Manitou	7.4	3.3	6.8	13.0	0.97	19.5	20.0	8.2	Fig. 15
Wheat	Neepawa	8.2	2.8	6.7	12.4	0.88	17.0	19.3	8.4	Fig. 16
Wheat	Neepawa	7.4	3.3	7.5	13.3	0.99	16.3	16.5	6.8	Fig. 17

to obtain a uniform air flow through the full length of the chaffer and sieve. Non-uniform air flow increased shoe loss and trash in the grain tank. A reduction in shoe loss would have permitted higher combining rates. It is recommended that the manufacturer consider modifications to improve the cleaning shoe performance.

Cylinder Loss and Grain Damage: Cylinder loss was low in all crops tested (FIGURES 13 to 17), while grain cracks were approximately 1% in wheat crops and less than 0.5% in barley crops. Cylinder loss and grain damage for the White 9700 were lower than for the reference combine.

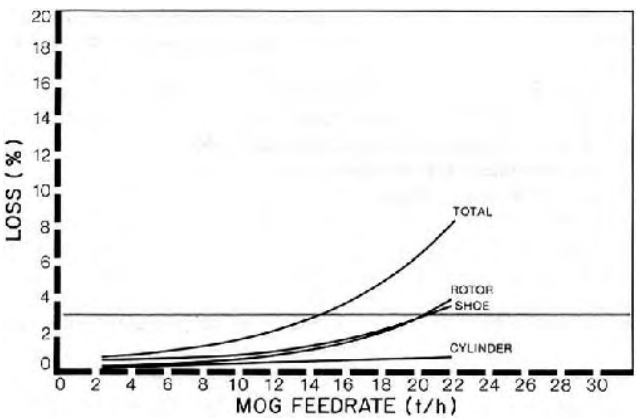


FIGURE 13. Grain Loss in Bonanza Barley.

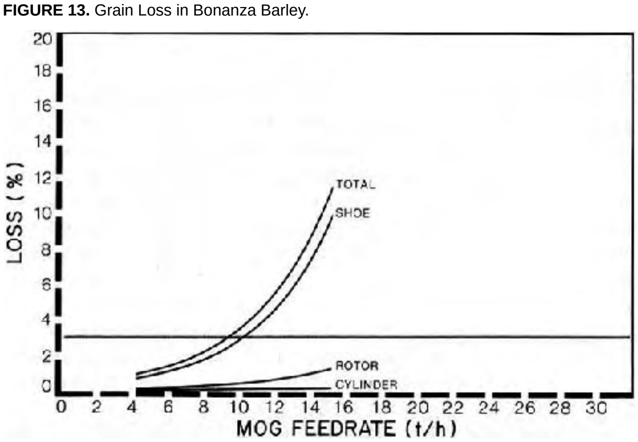


FIGURE 14. Grain Loss in Klages Barley.

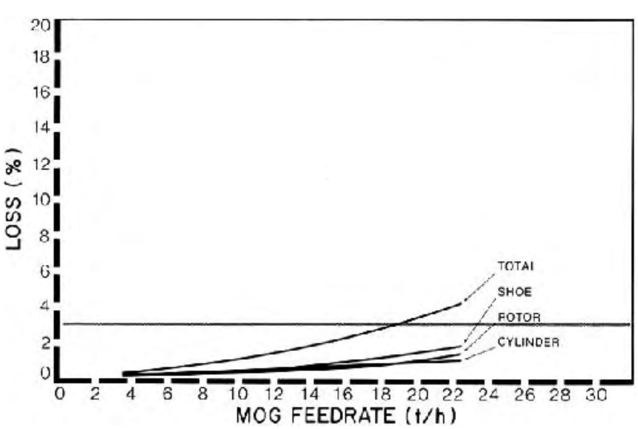


FIGURE 15. Grain Loss in Manitou Wheat.

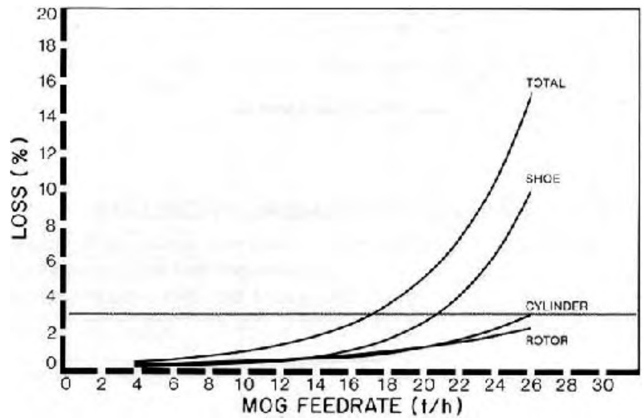


FIGURE 16. Grain Loss in Neepawa Wheat.

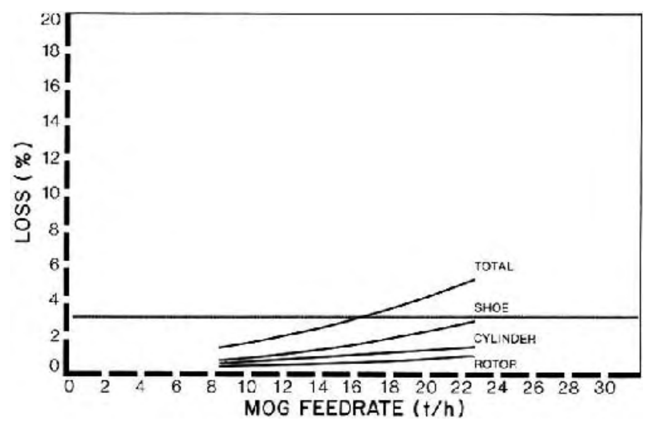


FIGURE 17. Grain Loss in Neepawa Wheat.

Body Loss: Grain leaked from the grain tank until the panel bolts were tightened. Grain also leaked past the header drive shaft seals in the grain tank. It is recommended that the manufacturer consider modifications to prevent grain leakage past these header drive shaft seals.

Comparison to Reference Combine: Comparing combine capacities is complex because crop and growing conditions affect combine performance with the result that slightly different capacity characteristics can be expected every year. As an aid in determining relative combine capacities the Machinery Institute uses a reference combine. This combine is operated alongside test combines whenever capacity measurements are made. This permits the comparison of loss characteristics of every test combine to those of the reference combine independent of crop conditions. The reference combine used by the Machinery Institute is commonly accepted in the prairie provinces and is described in the Machinery Institute evaluation report E0576C. See APPENDIX III for the Machinery Institute reference combine capacity results.

FIGURES 18 to 22 compare the total grain losses of the White 9700 to the Machinery Institute reference combine in the five crops described in TABLE 4. The shaded areas on the figures are 95% confidence belts. If the shaded areas overlap, the loss characteristics of the two combines are not significantly different whereas if the shaded areas do not overlap, losses are significantly different. The capacity of the White 9700 was much greater than that of the reference combine in both wheat and barley.

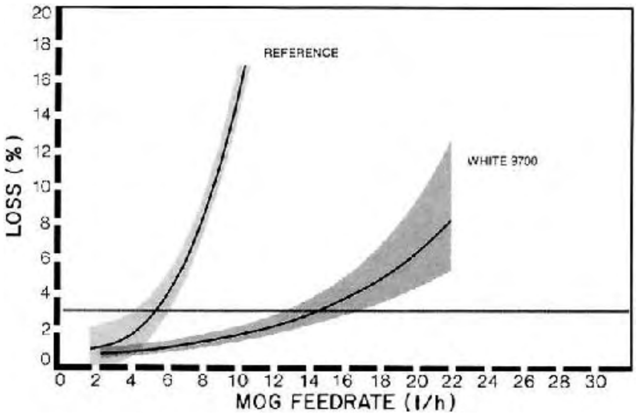


FIGURE 18. Total Grain Loss in Bonanza Barley.

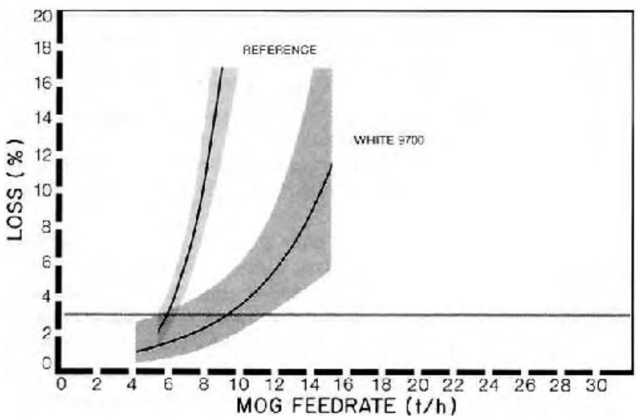


FIGURE 19. Total Grain Loss in Klages Barley.

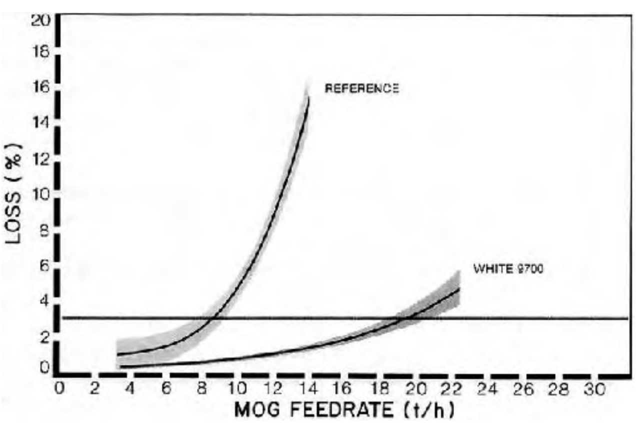


FIGURE 20. Total Grain Loss in Manitou Wheat.

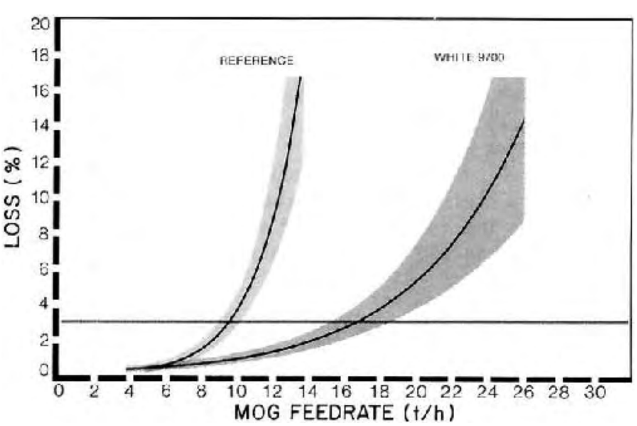


FIGURE 21. Total Grain Loss in Neepawa Wheat.

OPERATOR SAFETY

The operator's manual emphasized operator safety and illustrated safe operating procedures.

The White 9700 had adequate warning decals indicating hazardous areas. Moving parts were well shielded and most shields were easy to remove and replace. Hinged shields did not have props or hooks to hold them open. It is recommended that the manufacturer consider supplying locks to hold hinged shields open.

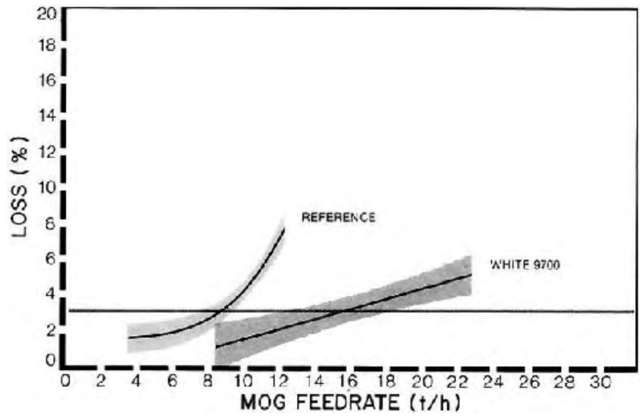


FIGURE 22. Total Grain Loss in Neepawa Wheat.

The operator had to climb onto the rear wheel to reach the engine compartment ladders. This was inconvenient and hazardous. Access to the grain tank from the operator's platform was also inconvenient. It is recommended that the manufacturer consider improving the ease of access to the engine compartment ladders and to the grain tank.

A header lock was provided. The lock should be in place when working near the header or when the combine is left unattended.

Most machine adjustments could be made safely, however, caution was required when entering between the wheel and ladder to adjust the concave. Caution was also required when leaving the combine while the engine was running as the separator clutch frequently failed to disengage even though the switch was turned off. A rocking wrench and hub were not provided for unplugging the table auger, which invites an operator to work in a potentially dangerous area.

The combine was equipped with a slow moving vehicle sign, warning lights, tail lights, turn signals, road lights and rear view mirrors to aid in safe road transport.

A fire extinguisher (class ABC) was supplied and should be carried on the combine at all times.

OPERATOR'S MANUAL

The operator's manual was clearly written, well illustrated and well organized. It contained much useful information on safe operation, controls, adjustments, crop settings, servicing and trouble shooting and machine specifications.

The suggested chaffer settings for rapeseed proved inadequate for all rapeseed crops encountered. It is suggested that the manufacturer consider revising the suggested chaffer opening for rapeseed.

DURABILITY RESULTS

MECHANICAL HISTORY

TABLE 5 outlines the mechanical history of the White 9700 during 115 hours of operation while harvesting about 460 ha (1135 ac). The intent of the test was functional performance evaluation. Extended durability testing was not conducted.

DISCUSSION OF MECHANICAL PROBLEMS

Windguard: The windguard and supports failed due to fatigue under normal operation. It is recommended that the manufacturer consider strengthening the windguard bar and support assembly.

TABLE 5. Mechanical History

Item	Operating Hours	Field Area ha
Drives		
-The connector link on the clean grain elevator chain came apart and was replace at	70	278
-The main drive belt jumped a groove on the drive pulley; the idler was aligned and belt guard adjusted at	76	300
-The hydraulic pump drive belt broke and was replaced at	80	308
-The return auger drive belt broke and was replaced at	85	325
Miscellaneous		
-The engine fuel lines leaked and were tightened at	64	239
-The windguard bar broke and was repaired at	76	300
-The tailings return auger shaft bent causing the bearing flange plate to fail. The shaft was straightened and new bearing flanges installed at	85	325
-A feeder conveyor slat broke and was repaired at	85	325
-A nut on a rear shoe support arm was lost and was replaced at	92	358
-A feed impeller bearing bolt broke at	100	390
and was replaced at	end of test	
-The windguard support arms broke and were repaired at	110, 115	438, 460

APPENDIX I
SPECIFICATIONS

MAKE:	White Self-Propelled Combine
MODEL:	9700 Harvest Boss
SERIAL NUMBER:	Header 8010550 NP Combine 9720727 Engine ZB70032U512019G
MANUFACTURER:	White Farm Equipment Canada Ltd. Brantford, Ontario
WINDROW PICKUP:	
-- make	White 600
-- type	roller and belt
-- pickup width	3680 mm
-- number of belts	6
-- teeth per belt	48 pair
-- type of teeth	Rilsan
-- number of rollers	2
-- height control	castor gauge wheels
-- speed control	variable speed hydraulic drive
-- speed range	0 to 1.8 m/s
HEADER:	
-- type	centre feed pickup head
-- width	4260 mm
-- auger diameter	500 mm
-- feed conveyor	3 roller chains, slatted conveyor
-- conveyor speed	3.3 m/s
-- range of picking height	-255 to 1245 mm
-- number of lift cylinders	2
-- raising time	2.7 s
-- lowering time	6.5 s
-- options	straight-cut head, soybean head, corn head
STONE PROTECTION:	
-- type	stone trap
-- ejection	manually operated access door
ROTOR:	
-- crop flow	axial
-- number of rotors	1
-- type	closed tube, 3 stage-inlet, thresh, separate, triple flighted intake auger, 3 threshing elements, 3 pairs of raspbars, 3 sweep plates, 3 sets of impeller blades
-- diameter	
- tube	492 mm
- feeding portion	634 mm
- threshing portion	800 mm
- separating portion	800 mm
-- length	
- feeding portion	725 mm
- threshing portion	1335 mm
- separating portion	2198 mm
total	4667 mm
-- drive	variable pitch belt and two speed gear box
-- speeds	
- low range	193 to 466 rpm
- high range	386 to 800 rpm (with limiter) 386 to 932 rpm (without limiter)
CONCAVES (Threshing):	
-- number	7
-- type	bar and wire grate
-- number of bars	27
-- configuration (narrow spaced)	26 intervals with 4.8 mm wires and 5.6 mm spaces
-- area total	1.607 m²
-- area open	0.714 m²
-- wrap	151 degrees
-- grain delivery to the shoe	grain pan
-- options	16 mm (58") spacing for grain, 32 mm (1-1/4") spacing for corn
CONCAVES (Separating):	
-- number	3
-- type	bar and wire, and a perforated formed metal
-- area total	2.611 m²
-- area open	1.437 m²
-- wrap	184 degrees
-- grain delivery to shoe	grain pan
-- options	perforated concave overlap plates
THRESHING AND SEPARATING CHAMBER:	
-- number of spirals	19
-- pitch of spirals	30 degrees
SHOE:	
-- type	opposed action
-- speed	300 rpm
-- chaffer sieve	adjustable lip, 2.40 m² with 66 mm throw
-- chaffer extension	adjustable lip, 0.28 m²
-- cleaning grain sieve	adjustable lip, 1.96 m² with 38 mm throw
-- options	perforated elevator doors, extensions, side hill attachments and miscellaneous sieves.
CLEANING FAN:	
-- type	single cross flow undershot diameter 700 mm
-- width	1365 mm
-- drive	variable speed belt
-- speed range	265 to 400 rpm, 380 to 580 rpm and 560 to 850 rpm
-- options	2nd wind board, slow speed fan drive (200 to 271 rpm)
ELEVATORS:	
-- type	roller chain with rubber flights
-- clean grain (top drive)	255 x 315 mm
-- tailings (top drive)	115 x 262 mm
GRAIN TANK:	
-- capacity	9.4 m³
-- unloading time	155 s
STRAW CHOPPER:	
-- type	rotor with 35 freely swinging flails speed 2800 rpm
ENGINE:	
-- make	Perkins
-- model	TV8-640
-- type	4 stroke, turbocharged diesel
-- number of cylinders	8
-- displacement	10.48 L
-- governed speed (full throttle)	2400 rpm
-- manufacturer's rating	185 kW @ 2400 rpm
-- fuel tank capacity	394 L
-- options	block heater
CLUTCHES:	
-- separator	electro-mechanical, belt tightener
-- header	electromagnetic
-- unloading auger	electromagnetic
NUMBER OF CHAIN DRIVES:	6
NUMBER OF BELT DRIVES:	12
NUMBER OF GEAR BOXES:	3
NUMBER OF PRELUBRICATED BEARINGS:	44
LUBRICATION POINTS:	
-- 10 h lubrication	14
-- 50 h lubrication	16
-- 500 h lubrication	4
TIRES:	
-- front	2, 30.5 L x 32 RI, 10-ply
-- rear	2, 16.9 L x 24 R3, 10-ply
TRACTION DRIVE:	
-- type	hydrostatic
-- speed ranges	
- 1st gear	0 - 5.8 km/h
- 2nd gear	0 - 12.1 km/h
- 3rd gear	0 - 28.2 km/h

OVERALL DIMENSIONS:

-- wheel tread front	3120 mm
-- wheel tread rear	3040 mm
-- wheel base	4010 mm
-- transport height	3953 mm
-- transport length	10110 mm
-- transport width	4735 mm
-- field height	4285 mm
-- field length	8905 mm
-- field width	2940 mm
-- unloader discharge height	3900 mm
-- unloader clearance height	3730 mm
-- unloader reach	3201 mm
-- turning radius	
- left	8070 mm
- right	8470 mm

MASS (Empty Grain Tank):

-- right front wheel	3650 kg
-- left front wheel	4430 kg
-- right rear wheel	2600 kg
-- left rear wheel	2600 kg
TOTAL	13280 kg

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations for the capacity results shown in FIGURES 13 to 17 are presented in TABLE 6. In the regressions, C = cylinder loss in percent of yield, S = shoe loss in percent of yield, R = rotor loss in percent of yield, F = the MOG feedrate in t/h, while $\ln$ is the natural logarithm. Sample size refers to the number of loss collections. Limits of the regressions may be obtained from FIGURES 13 to 17 while crop conditions are presented in TABLE 4.

TABLE 8. Regression Equations

Crop - Variety	Fig. No.	Regression Equations	Simple Correlation Coefficient	Variance Ratio	Sample Size
Barley - Bonanza	13	$C = 0.07 + 0.03F$ $S = 0.51 + 2.9 \times 10^{-4}F^2$ $\ln R = -2.19 + 0.16F$	0.96 0.94 0.96	71.58[2] 45.80[2] 78.69[2]	8
Barley - Klages	14	$\ln C = -3.55 + 0.13F$ $\ln S = -1.29 + 0.24F$ $\ln R = -2.57 + 0.19F$	0.95 0.89 0.95	46.11[2] 18.55[2] 11.09[2]	7
Wheat - Manitou	15	$\ln C = -4.03 + 1.25 \ln F$ $\ln S = -5.37 + 1.87 \ln F$ $\ln R = -2.47 + 0.12F$	0.93 0.97 0.94	42.82[2] 103.05[2] 57.12[2]	9
Wheat - Neepawa	16	$\ln C = -2.77 + 0.15F$ $\ln S = -3.51 + 0.22F$ $\ln R = -1.96 + 0.11F$	0.98 0.96 0.97	157.33[2] 73.34[2] 104.72[2]	8
Wheat - Neepawa	17	$C = -0.13 - 0.07F$ $S = 0.26 + 5.03 \times 10^{-3}F^2$ $\ln R = -2.26 + 0.10F$	0.91 0.81 0.91	28.46[2] 11.41[1] 29.14[2]	8

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

APPENDIX III
MACHINERY INSTITUTE REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 23 and 24 present the capacity results for the Machinery Institute reference combine in wheat and barley harvested from 1977 to 1981.

FIGURE 23 shows capacity differences in Neepawa wheat for the five years. Most 1981 Neepawa wheat crops shown in TABLE 7 were of average straw yield and better than average grain yield. Most of the crops were average to hard-to-thresh while grain and straw moisture content were average.

TABLE 7. Capacity of the Machinery Institute Reference Combine at a Total Grain Loss of 3% of Yield.

FIGURE 24 shows the capacity differences in six-row Bonanza barley for 1977 to 1978 and for 1981, two-row Fergus barley for 1979 and two-row Hector barley for 1980. The 1981 Bonanza barley crop shown in TABLE 7 was of average straw and grain yield, easy-to-thresh, and had average straw and moisture content.

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

	Crop Conditions							Capacity Results			
					Grain Moisture			MOG Feedrate	Grain Feedrate	Ground Speed	
Year	Crop	Variety	Width of Cut m	Crop Yield t/ha	Straw %	Grain %	MOG/G	t/h	t/h	km/h	Loss Curve
1981	Barley	Bonanza	7.2	3.33	7.2	12.6	0.67	5.6	8.4	3.5	Fig. 24
	Barley	Klages	7.4	2.86	7.1	12.0	0.68	6.0	8.8	4.2	
	Wheat	Manitou	7.4	3.46	8.3	13.8	0.96	8.5	8.9	3.5	
	Wheat	Neepawa	8.2	3.69	6.4	11.9	0.85	9.5	11.2	3.7	Fig. 23
	Wheat	Neepawa	7.4	3.29	8.2	13.7	0.93	9.2	9.9	4.1	
1980	Barley	Hector	6.1	3.48	13.8	14.5	0.69	5.5	8.0	3.8	Fig. 24
	Barley	Hector	6.1	3.16	13.4	14.4	0.68	5.8	8.5	4.4	
	Wheat	Neepawa[1]	12.2	2.87	7.2	13.2	0.88	9.4	10.6	3.0	
	Wheat	Neepawa	6.1	3.12	6.0	11.4	0.98	10.1	10.3	5.4	Fig. 23
	Wheat	Neepawa[1]	12.2	3.09	6.2	12.2	1.02	10.2	10.0	2.7	
	Wheat	Neepawa	6.1	3.00	4.9	10.8	0.91	10.3	11.3	6.2	
1979	Barley	Klages	6.1	3.67	dry	11.7	0.64	6.8	10.6	4.7	
	Wheat	Neepawa	7.3	2.77	dry	14.1	1.21	9.5	7.8	3.9	
	Wheat	Neepawa	6.1	2.67	dry	14.3	1.09	9.7	8.9	5.4	Fig. 23
	Barley	Fergus	7.3	3.46	dry	12.5	0.77	7.3	9.5	3.7	Fig. 24
1978	Wheat	Canuck	7.3	2.54	7.1	12.1	1.15	11.8	10.3	5.6	
	Wheat	Lemhi[1]	11.0	2.13	6.6	12.0	0.75	10.9	14.5	6.2	
	Wheat	Neepawa	6.1	4.37	10.4	15.9	1.04	9.3	8.9	4.5	Fig. 23
	Barley	Bonanza	6.1	4.06	7.7	13.5	0.68	6.1	9.0	3.6	Fig. 24
1977	Wheat	Neepawa	6.1	3.97	13.4	14.6	0.79	11.1	14.1	5.8	Fig. 23
	Barley	Bonanza	7.3	4.74	25.7	14.6	0.84	7.9	9.4	2.7	Fig 24

[1]Side by Side Double windrow

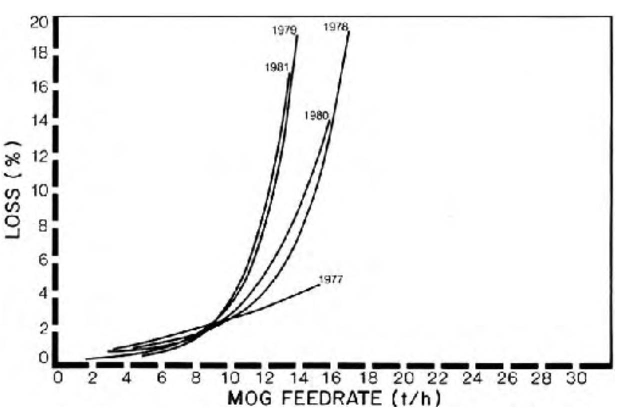


FIGURE 23. Total Grain Loss for the Reference Combine in Neepawa Wheat.

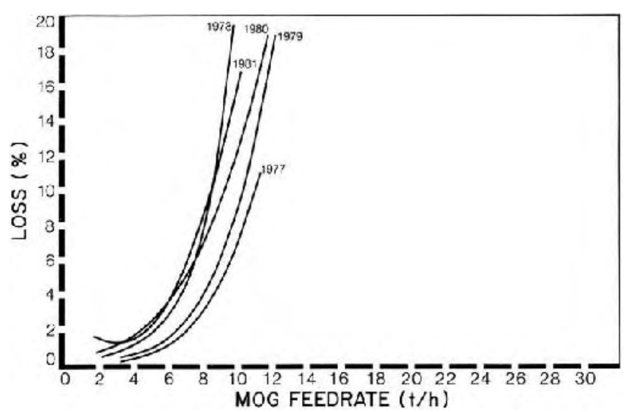


FIGURE 24. Total Grain Loss for the Reference Combine in Barley.

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in Machinery Institute Evaluation Reports:

(a) excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory

APPENDIX V
CONVERSION TABLE

1 kilometre/hour (km/h)	= 0.6 miles/hour (mph)
1 hectare (ha)	= 2.5 acres (ac)
1 kilogram (kg)	= 2.2 pounds (lb)
1 tonne (t)	= 2200 pounds mass (lb)
1 tonne/hectare (t/ha)	= 0.5 ton/acre (ton/ac)
1 tonne/hour (t/h)	= 37 pounds/minute (lb/min)
1 kilowatt (kW)	= 1.3 horsepower (hp)
1 litre/hour (L/h)	= 0.2 Imperial gallons/hour (gal/h)
1 metre (m)	= 3.3 feet (ft)
1 millimetre (mm)	= 0.04 inches (in)

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