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Evaluation Report 142

International Harvester 1460 Self-Propelled Combine

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

INTERNATIONAL HARVESTER 1460 SELF-PROPELLED COMBINE

MANUFACTURER:
International Harvester Company
East Moline, Illinois 61244

DISTRIBUTOR:
International Harvester of Canada
660 Wall Street
Winnipeg, Manitoba
R3C 2W8

RETAIL PRICE:
$69,226.00 May, 1979, f.o.b. Humboldt, with 4.0 m header, 3.4 m belt pickup with hydraulic drive, shaft speed monitor, stone retarder, pre-cleaner, cab heater, air conditioner and windshield wiper.

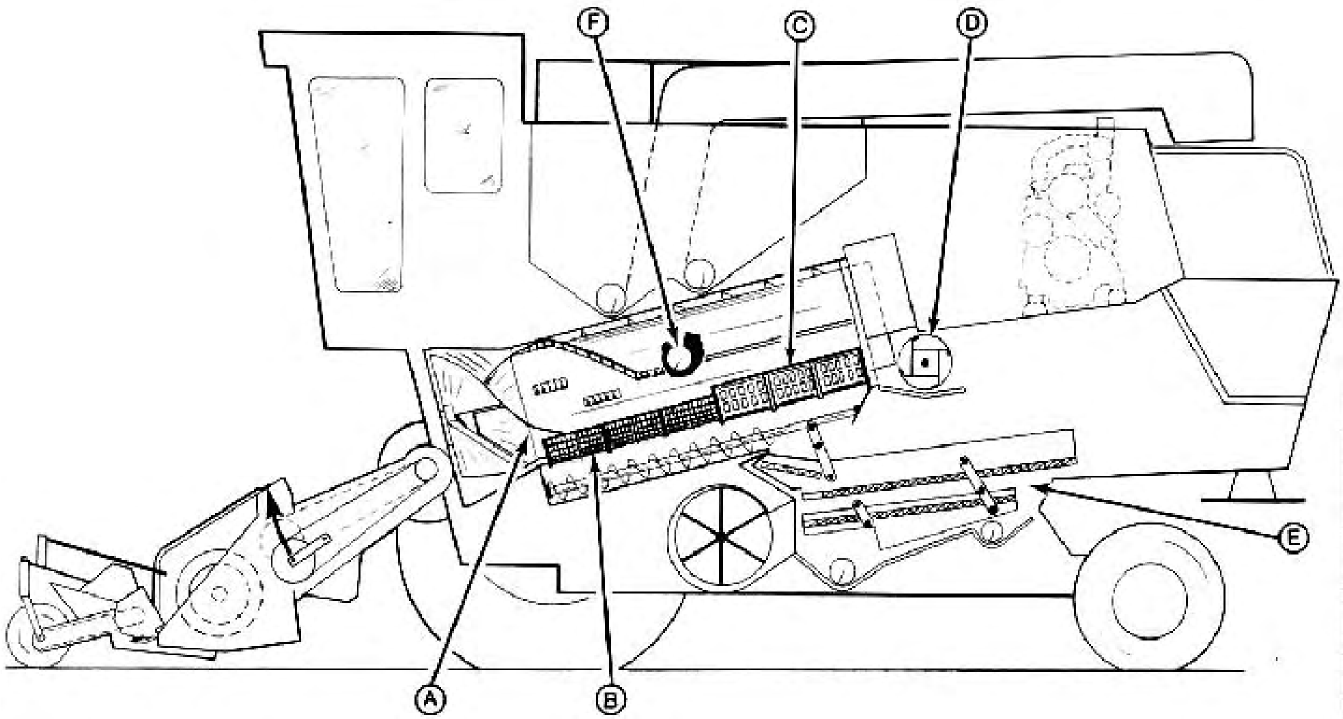

FIGURE 1. International Harvester 1460: (A) Rotor, (B) Threshing Concaves, (C) Separating Concaves. (D) Back Beater, (E) Shoe, (F) Tailings Return.

SUMMARY AND CONCLUSIONS

Functional performance of the International Harvester 1460 self-propelled combine was very good in dry grain and oil seed crops. Functional performance was good in tough crops and fair in damp crops.

The MOG Feedrate[1] at 3% total grain loss varied from 17.4 t/h (639 lb/min) in 2.2 t/ha (33 bu/ac) Canuck wheat to 8.6 t/h (316 lb/min) in 3.73 t/ha (69 bu/ac) Bonanza barley. In 2.21 t/ha (33 bu/ac) Lemhi wheat the total grain loss at engine power limit reached only 2.5% of yield at a MOG Feedrate of 17.3 t/h (636 lb/min). The capacity of the International Harvester 1460 was much greater than the capacity of the PAMI reference combine and the 1460 had much lower grain losses when operating at the same feedrate. Rotor and shoe losses were low over the full operating range in wheat crops, but increased significantly in barley crops at high feedrates. Cylinder losses were usually low over the full operating range.

Capacity was reduced in bunchy windrows as the crop had to be funnelled into a small area to feed the rotor. Feeding was much more uniform in well formed windrows than in poorly formed windrows. Maximum capacity was obtained with uniform parallel single windrows.

Engine power limited the capacity in most difficult-to-thresh crops. Fuel consumption varied from 23 to 27 L/h (5 to 6 gal/h). The rotary radiator air inlet screen was very effective in preventing radiator plugging. Heavy tail winds necessitated frequent attention to the engine air intake filters, which plugged frequently in severe conditions. The engine started well, but at temperatures below +2° C, ether was needed to start the cold engine. The steering and braking systems were excellent. By using the individual wheel brakes it was possible to pick most sharp corners formed by self-propelled windrowers. Instruments and controls were conveniently positioned. All controls were responsive. The cab was well pressurized and dust free. Operation of the heater and air conditioning system was excellent. Sound level at the operator's station was about 77 dBA with the pressurization fan off and 80 dBA at maximum fan speed.

Header visibility was good both in the daytime and at night. Grain level visibility was excellent. Rear visibility was restricted. Rear view mirrors were required for road transport. Normal caution was required when operating the International Harvester 1460 at maximum transport speed of 28 km/h (17.5 mph).

The International Harvester 1460 was quite easy to adjust for specific field conditions. Adjustment would have been easier if return tailings could have been inspected. The optional shaft speed monitoring system was helpful by warning the operator of malfunction. Ease of servicing was very good. The pickup had poor feeding characteristics, delivering the crop into the table auger, reducing capacity.

The table auger and feeder had good capacity in dry grain crops, but capacity was reduced by poor feeding from the pickup to the table auger. Capacity was reduced in heavy bunchy rapeseed and in damp grain crops due to choking and plugging of the table auger and feeder. The rotor was positive and aggressive. Plugging was infrequent, even in tough crops. Unplugging the rotor was inconvenient.

[1]MOG Feedrate (Material-other-than grain feedrate) is the weight of straw and chaff passing through a combine per unit time.

The stone retarder was effective in preventing most roots, stones or wads from entering the rotor, but unplugging was difficult and inconvenient. Smaller stones caused minor rotor housing and concave damage.

No serious safety hazards were noticed when operated according to the manufacturer's recommended procedures. The operator's manuals were well illustrated and contained useful information on servicing and adjustments for most crops.

A few minor durability problems occurred during the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Supplying lighting for the switches on the right instrument panel.
2. Modifying the pickup and header to improve feeding.
3. Modifying the shield latch and retainer post to provide more convenient access to the table auger drive hub.
4. Modifying the separating concave to prevent bridging.
5. Modifying the concave support pins to prevent concave creep.
6. Modifying the shoe to reduce plugging in wild oat infested crops.
7. Modifications to reduce wear on the rotor feed impellers.
8. Providing initial settings for rapeseed in the operator's manual.
9. Modifying the alternator to prevent foreign material entry.
10. Providing guards for the feeder and separator switches to prevent accidental machine engagement.

Chief Engineer E. O. Nyborg
Senior Engineer L. G. Smith
Project Engineer P. D. Wrubleski

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Improved lighting of the right hand console and switches will be investigated.
2. Design changes have been made and parts will be available during the 1979 season to improve feeding into the header with the windrow pickup.
3. Modification to improve convenience of access to the platform auger drive hub will be investigated.
4. The cage holes have been rotated to eliminate plugging between the lower row of cage holes and the cage angle.
5. The pin on the concave support was incorrectly welded which resulted in reduced pin strength. Quality audit is now standard procedure at the plant to check this welding.
6. Cleaning system performance in specified conditions will be further investigated.
7. Changes have been made in material specification to reduce wear in the impeller area.
8. Initial combine settings for rapeseed will be added to the owner's manual.
9. For dusty or severe conditions a special brushless alternator is available as optional equipment.
10. Switches include an interlock to prevent engine starting with the switches engaged. The switches are located to provide the operator with quick disengagement during operation.

GENERAL DESCRIPTION

The International Harvester 1460 is a self-propelled combine with one longitudinally mounted, axial, threshing and separating rotor. Threshing occurs at the front section of the rotor while separation of grain from straw is accomplished with full length threshing and separation concaves. A cleaning shoe is used, with return tailings delivered to the third threshing concave. A reinforced front feeder drum acts as a stone retarder.

The test machine was equipped with a 127 kW turbocharged 6-cylinder diesel engine, a 4.0 m header, a 3.4 m hydrostatically driven two roller belt pickup and the optional accessories listed on PAGE 2.

Traction drive is through a three-speed transmission and hydrostatic drive system with an intermediate clutch pedal. The International Harvester 1460 is equipped with hydraulic wheel brakes, power steering and a pressurized operator's cab.

Separator and header drives are electrically controlled through hydraulically actuated belt tighteners. The grain tank unloading drive is lever controlled through an over-centre belt tightener.

Hydraulic levers control the ground speed, header height and unloading auger swing. Pickup and rotor speeds can be adjusted on-the-go from the operator's platform. Concave clearance is adjusted with a ratchet lever located on the left combine side. Fan speed is adjusted with a hand wheel controlling a variable speed belt drive, while the chaffer and sieve are adjusted with levers at the rear of the shoe. There is no provision to safely and quickly sample the return tailings.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The International Harvester 1460 was operated in a variety of Saskatchewan and Alberta crops (TABLES 1 and 2) for 127 hours while harvesting about 293 ha. It was evaluated for ease of operation, ease of adjustment, rate of work, grain loss characteristics, feeding and threshing characteristics, operator safety and suitability of the operator's manual. Throughout the test, comparisons were made to the PAMI reference combine.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield t/ha	Swath Width m	Hours	Field Area ha
Barley	Bonanza	3.6	6.1	11.0	27
Barley	Klages	2.8	7.3	7.0	25
Oats	Rodney	2.0	7.3	3.0	5
Rapeseed	Midas	1.9	6.1 to 7.3	25.0	56
Rapeseed	Regent	1.7	6.1	7.5	20
Rye	Sangaste	2.5	6.1	3.5	5
Wheat	Canuck	2.6	5.5 to 6.1	9.5	18
Wheat	Fielder	2.2	11.0	4.5	16
Wheat	Glenlea	4.3	6.1	5.5	13
Wheat	Lemhi	2.0	11.0	1.5	5
Wheat	Neepawa	3.0	6.1	21.5	51
Wheat	Sundance	2.8	5.5 to 6.1	27.5	52
Total					293

TABLE 2. Operation in Stony Fields

Field Conditions	Hours	Field Area ha
Stone Free	34	81
Occasional Stones	80	181
Moderately Stony	13	31
Total	127	293

RESULTS AND DISCUSSION

EASE OF OPERATION

Operator Location: The International Harvester 1460 was equipped with an operator's cab as standard equipment. The cab was positioned ahead of the grain tank, slightly left-of-centre, giving good visibility to the left, front and right. Visibility to the rear was obstructed necessitating caution when maneuvering in confined areas. Rear view mirrors marginally improved rear visibility for road transport. Header visibility was good both in the daytime and at night. The grain level could be viewed through a large window but grain and return tailings could not be sampled from the operator's seat.

The operator's seat was comfortable and easy to adjust. The steering column was readily adjustable. The cab was not high enough to permit standing operation, however, seat position and control location made standing unnecessary.

The cab was relatively dust free. The cab pressurization system effectively filtered the incoming air and reduced dust leaks. Since the inlet air filter was located above the cab door, upon exit the operator was showered with dust when closing the door. The heating and air conditioning systems provided suitable cab temperatures in all operating conditions.

Total noise at operator ear level was only 77 dBA with the pressurizing fan off and 80 dBA with the fan at maximum speed.

Controls: The control arrangement is shown in FIGURE 2. Most controls were conveniently placed, easy to use and responsive. Caution is required when actuating the responsive hydrostatic drive lever, to prevent sudden changes in groundspeed. Rotor speed was electrically controlled through a variable speed belt drive. The hydraulically controlled pickup drive and the responsive header lift gave the operator good control. Header lift was quick enough to suit all conditions; header drop rate was adjustable.

Steering: Steering and maneuverability were excellent. The power steering was smooth and responsive. The turning radius was about 6.4 m and by using the individual wheel brakes it was possible to pick most corners formed by self-propelled windrowers. The wheel brakes were responsive and effective. The hydrostatic drive also made it easy to turn corners, by stopping and backing up, since no clutching or gear shifting was needed.

Instruments: The instrument console (FIGURE 2) included gauges for engine oil pressure, coolant temperature, battery charging, fuel level and engine hours. Indicator lights were provided for engine oil pressure, battery charging, coolant temperature and parking brake. The engine, ground, rotor or fan speeds were alternately read on a digital tachometer.

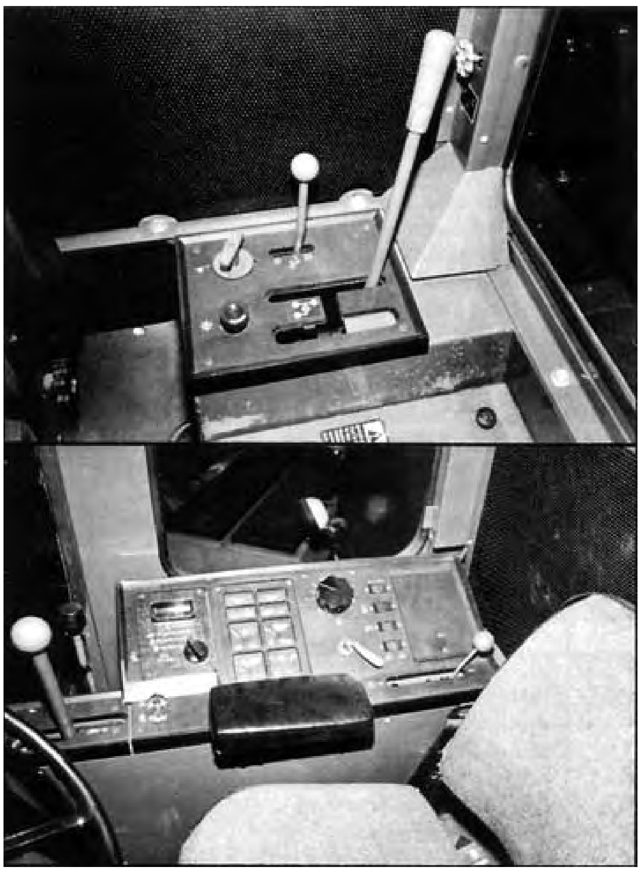

FIGURE 2. Control Layout and Instrument Console.

The optional shaft speed monitor (FIGURE 3) was useful in detecting component stoppage. It monitored the fan, shoe, tailings elevator, clean grain elevator and beater, signalling the operator if any shafts fell below 70% of normal speed. The rotary radiator intake screen was also monitored.

Lights: The International Harvester 1460 was equipped with five front lights and three rear lights. Header lighting, long range front lighting and lighting for the grain tank, unloading auger and area behind the combine all were very good.

Lighting for the switches on the right instrument panel was unsatisfactory. It is recommended that the manufacturer supply lighting for these switches.

Engine: The engine had ample power for normal combining but operated near its power limit when combining damp crops on soft, hilly fields. Average fuel consumption varied from 23 to 27 L/h. The engine was located behind the grain tank and was very accessible.

The rotary radiator air inlet screen was very effective in preventing radiator plugging. Although the rotary screen plugged frequently when operating with a tail wind, the screen could usually be cleaned by stopping and idling the engine. Cleaning of the radiator was facilitated by the offset rotary screen and two access doors. Regular washing of the radiator, oil cooler and air conditioning heat exchanger is desirable to remove accumulated dust.

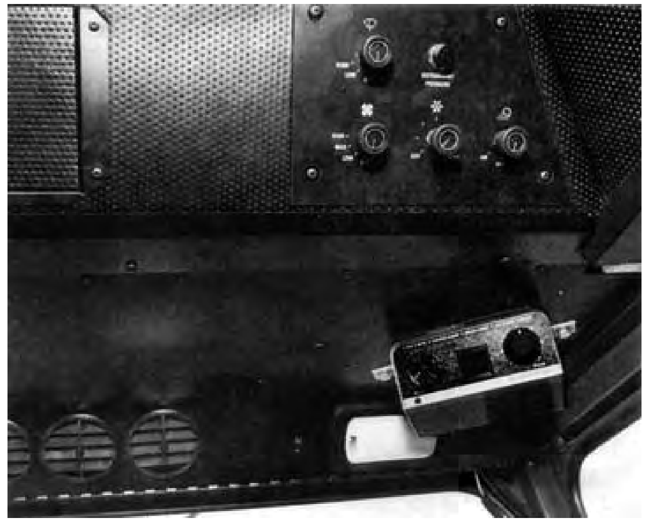

FIGURE 3. Environmental Controls and Shaft Speed Monitor.

The engine air intake used a screen precleaner, an aspirated precleaner, a centrifugal bowl cleaner and two dry filters. An air cleaner service indicator was mounted on the air filter. Frequent filter cleaning was needed when operating in heavy tail winds.

The engine started easily. If ambient temperature dropped below +2°C, the ether starting aid had to be used to start the cold engine. Engine oil consumption was insignificant throughout the test.

The fuel tank inlet was located 2.3 m above the ground, causing some problems when the tank was filled from average height gravity fuel tanks.

Stability: The International Harvester 1460 was very stable, even with a full grain tank. The centre of gravity, with a three-quarters full grain tank was about 1920 mm above ground, 830 mm behind the drive wheels and on the combine centre line. Normal care had to be used when turning corners on hillsides.

Normal caution was required when operating the International Harvester 1460 at maximum transport speed of 28 km/h.

Grain Tank: The grain tank held 6.34 m3 of wheat. Unloading a full hopper of dry wheat took 112 seconds. The grain tank filled evenly in all crops.

The unloading auger had excellent clearance and reach for easy unloading on-the-go.

Straw Spreaders: The straw spreader attachment performed well in most crops. Maximum spreading width varied from 3.1 to 4.3 m depending on straw and wind conditions, and spreading was inadequate for swath widths greater than 5 m. If the straw was to be windrowed, the paddle assemblies were easily removed.

As is common with axial combines, the rotor broke straw into short lengths and a straw chopper was unnecessary. As a result, poor pickup performance and reduced bale quality sometimes occurred when baling this straw.

Plugging: The table auger and feeder were aggressive. Occasional table auger plugging occurred in bunchy rapeseed or damp heavy crops. In such crops, increasing the auger clearance was important. When properly adjusted, table auger plugging was infrequent. Plugging would be reduced if feeding characteristics were improved between the pickup and table auger. A rocking wrench and hub were provided to facilitate table auger unplugging. It is recommended that the manufacturer consider modifying the shield latch and retainer post to provide more convenient access to the auger drive hub.

Although the feeder conveyor was aggressive, plugging occurred in bunchy or damp, heavy crops, partly due to the narrow feeder housing. A rocking wrench was provided for the upper feeder hub to facilitate unplugging.

The rotor was very aggressive and positive. Backfeeding never occurred. Rotor plugging occurred infrequently. If the rotor plugged, it could usually be unplugged by lowering the concave. On one occasion, in which serious plugging occurred, it took about one-half hour to unplug the rotor. Although the rotor drive shaft was equipped with a rocking hub, it was ineffective in freeing the plug, which had to be removed by hand. Rotor access was inconvenient as the side panels and the concave support linkages must be removed, allowing the concave to swing free from the rotor.

As with most combines, dust and chaff collected inside the rasp bars, causing rotor imbalance and requiring cleaning.

Straw and chaff bridged between the left side sheet of the combine and the separating concave (FIGURE 4), thus decreasing separating area. Plugging was caused by straw hairpinning around a concave support member. This problem was eliminated by installing a cover, which prevented hairpinning. It is recommended that the manufacturer consider modifying the separating concave to prevent bridging of straw and chaff.

FIGURE 4. Bridging Between Concave and Sidewall.

The chaffer sieve centre section plugged (FIGURE 5) when combining wild oat infested crops. This was attributed to the lip design which retained the wild oat seeds, and also to lower air velocities at the centre of the chaffer, it is recommended that the manufacturer consider modifications to reduce centre-section chaffer plugging in wild oat infested crops.

FIGURE 5. Chaffer Plugging in Wildoats.

Stone Protection: The test machine was equipped with an optional stone retarder drum located at the front of the feeder (FIGURE 6). The clearance between the retarder drum and feeder floor could be set to limit the size of objects which could pass up the feeder. When a straw wad or foreign object was trapped between the reinforced feeder drum and feeder housing bottom, the conveyor stopped. The conveyor then had to be reversed by hand to remove the object. Though the stone retarder was effective in preventing most roots, stones or wads from entering the rotor, unplugging was difficult and inconvenient. Smaller stones caused minor concave and rotor damage.

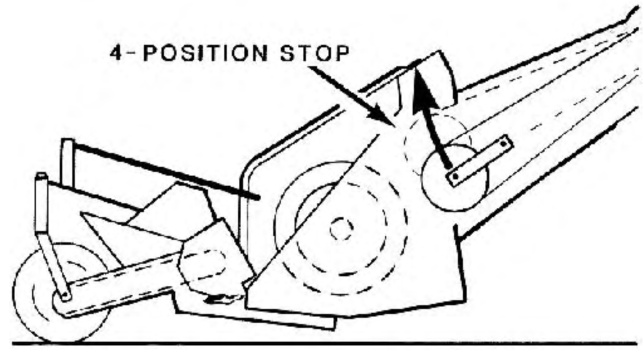

FIGURE 6. Stone Retarder.

In bunchy rapeseed windrows, the stone retarder stops had to be set to their highest position to increase feeder capacity. In this position, only limited stone protection was provided.

Pickup: The International Harvester 1460 was equipped with a 3.4 m, two roller, belt pickup with nylon teeth. Pickup pitch changed when the header was raised or lowered. Pickup performance was good if operated with the belts nearly parallel to the ground. If pickup pitch increased, crop fed into the centre of the table auger rather than under it (FIGURE 7). Although operating the pickup parallel to the ground was possible in non-stony fields, this was less desirable in light crops and stony fields, where the stone picking frequency increased. Ground speeds of 4.8 km/h and over were often required to properly load the International Harvester 1460, and feeding at these speeds led to plugging as crop often fed over the table auger. It is recommended that the manufacturer consider modifying the pickup and header to improve feeding.

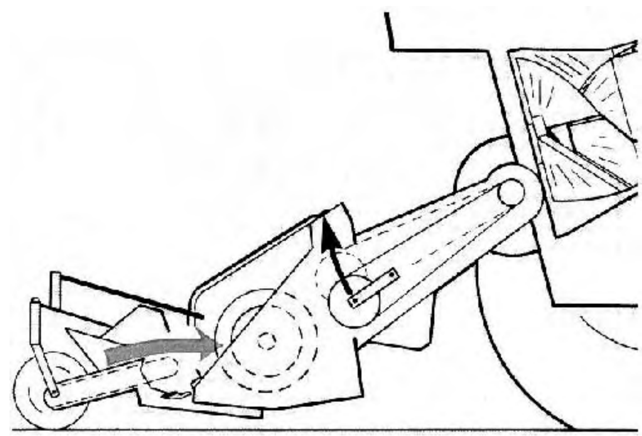

FIGURE 7. Crop Flow from Pickup to Auger.

In buckwheat infested windrows, plugging frequently occurred between the rear pickup roller and the stripper bar, causing belt slippage and necessitating weed removal by hand. No adjustments remedied this problem.

Pickup speed, which could be varied hydrostatically with a hand wheel inside the combine cab, was adequate for all crops.

Machine Cleaning: As with most combines, completely cleaning the International Harvester 1460 for combining seed grain was laborious and time-consuming. The chaffer and sieve were easy to remove for cleaning of the tailings and clean grain augers. The chaffer and clean grain sieves were very difficult to clean as grain and weed seeds accumulated in the lips. The augers beneath the concaves were cleaned after removing the side sheets. The grain tank and unloading auger intake were very difficult to clean due to cross members and obstructions. A heavy debris accumulation occurred in the engine compartment beneath the main drives, as the rear of the rotor was not sealed.

Lubrication: The International Harvester 1460 had 45 pressure grease fittings. Five needed greasing every 10 hours, twentytwo needed greasing every 50 hours, six needed greasing every 100 hours, while three had to be greased at 200 hours and nine had to be greased at 500 hours. Ease of lubrication was excellent.

Engine, gear box and hydraulic oil levels required regular checking.

EASE OF ADJUSTMENT

Field Adjustments: The International Harvester 1460 was easy to adjust, and could usually be set by one person. Since return tailings could not be inspected, the operator did not have complete feel of the effect of settings on performance.

Concave Adjustment: The rotor was equipped with an adjustable threshing concave and a stationary separating concave (FIGURE 8). Access to the concave was through doors on both sides of the combine.

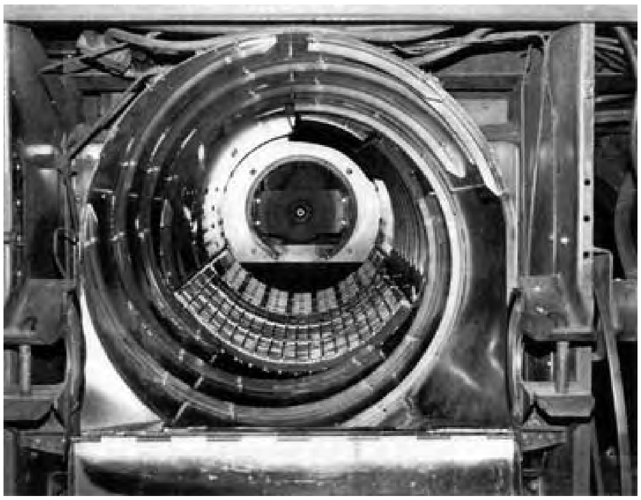

FIGURE 8. Threshing and Separating Concaves.

Levelling and adjustment of initial concave clearance was quite convenient. The front threshing concaves were removable in three individual segments so one segment was removed while initial adjustments were made using the other two segments for reference. Suitable initial concave settings (FIGURE 9) were 55 mm at the leading bar and 2 mm at the trailing bar. The concave stops were then secured and the indicator set to the zero position.

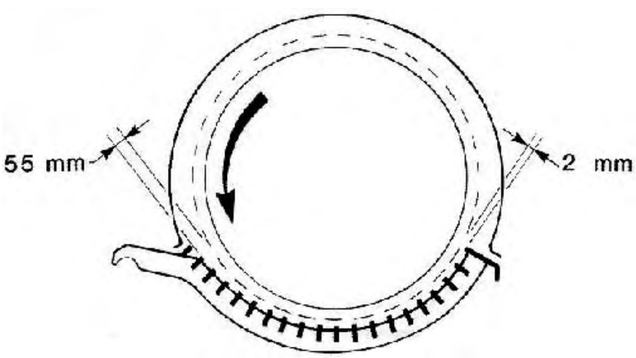

FIGURE 9. Initial Concave Settings.

Once the concave had been initially set, clearance was easily adjusted with the lever beneath the operator's platform. The control linkage held the leading and trailing concave bars parallel to the rotor axis. Leading bar clearance varied little over the adjustment range. Leading bar clearances could be varied from 54 to 56 mm while trailing bar clearances could be varied from 2 to 46 mm.

Concave adjustments were not needed as frequently as on conventional combines with tangential threshing cylinders. Suitable concave settings were number 2 in fall rye, number 1 in winter wheat, number 3 to 6 in rapeseed, number 2 in barley and number 0 to 1 in hard-to-thresh spring wheat. Greater differences in threshing were obtained with rotor speed adjustment than with concave clearance adjustment.

Capacity tests in wheat were conducted with all narrow spaced concaves (FIGURE 10), while in barley tests were conducted with the narrow spaced concave in the first position, and wide spaced concaves (FIGURE 10) in the second and third position.

FIGURE 10. Narrow and Wide Spaced Concaves.

Channels were provided on the outside of the rear separation grates across the centers of the slotted holes, reducing the amount of chaff that fell to the cleaning system. Though the channels could either be removed to allow a larger amount of chaff to pass, or else mounted to the inside of the grate to provide more aggressive separation, neither adjustment was necessary throughout the test.

Rotor Adjustment: The rotor (FIGURE 11) was powered through a two-speed gear box and a variable speed drive, adjustable electrically from the operator's seat.

The variable drive provided speeds from 330 to 690 rpm in low range and 640 to 1320 rpm in high range. This range was adequate for all prairie crops encountered during the test. Suitable rotor speeds were 900 rpm in dry wheat, 1000 rpm in tough wheat, 800 rpm in dry barley, 900 rpm in tough barley, and 600 rpm in rapeseed. Grain crackage varied from 0.9 to 1.3% in Canuck wheat, from 1.5 to 1.8% in Lemhi wheat, from 0.6 to 1.8% in

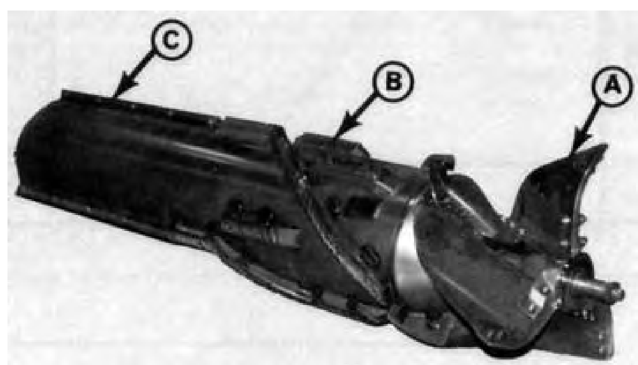

FIGURE 11. Rotor (A) Impellers, (B) Rasp Bars, (C) Separation Fins.

Neepawa wheat and was about 0.7% in Bonanza barley (FIGURE 12). Crackage was about 1.3% in Regent rapeseed and about 1.5% in Midas rapeseed.

Wear on the rotor feed impellers was high, due to aggressive fin action. It is recommended that the manufacturer consider modifications to reduce impeller wear. The rotor rasp bars were in good condition at the end of the test, however, wear was greater than on conventional combines with tangential threshing cylinders.

Rotor Transport Vane Adjustment: Throughout the test, the rotor transport vanes were operated in full pitch position. The vanes could also be set to the half pitch position, but this was found to be unnecessary throughout the test.

Back Beater Adjustment: The discharge beater bottom is adjustable and was set at 19 mm from the beater blade tips. This was not adjusted throughout the test.

Shoe Adjustments: The shoe was convenient to adjust.

Fan speed was varied with a hand wheel (FIGURE 13) while the chaffer, chaffer extension and clean grain sieves were adjusted with levers at the rear of the shoe. There was no provision to safely and conveniently sample tailings to aid in machine adjustment.

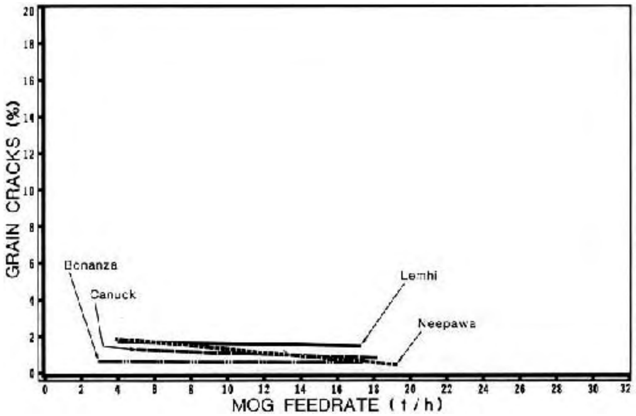

FIGURE 12. Grain Damage.

FIGURE 13. Fan Adjustment.

Shoe performance was satisfactory in most crops. Total dockage in the grain tank including cracks, white caps and chaff varied from 1 to 4% when properly adjusted. In addition, the shoe had a characteristically high return. As previously discussed, plugging occurred in the centre section of the chaffer in wild oat infested crops.

Feeding off-centre had little effect on shoe performance as the International Harvester 1460 has only one rotor. Chaff and grain distribution were affected by rotor speed, concave clearance, feedrate and sideslope. As with most combines, shoe loss increased noticeably when combining on side slopes greater than 5°, due to non-uniform shoe loading.

Header Adjustments: The International Harvester 1460 was tested only with a pickup attachment for windrowed crops. Straight combining attachments were not evaluated. The table could be removed from the feeder by one man in about 10 minutes. A complete header and feeder assembly could also be removed from the combine, taking two men about 25 minutes.

The table auger was easy to adjust both vertically and horizontally and only routine adjustment was needed when moving between grain and oilseed crops.

Slip Clutches: Individual slip clutches protected the table auger, feeder conveyor, shoe shaker and delivery auger drive, and the tailings and clean grain elevator drive.

RATE OF WORK

Average Workrates: TABLE 3 presents the average workrates for the International Harvester 1460, at acceptable loss levels, in all crops harvested during the test. Average workrates are affected by crop conditions in a specific year and should not be used for comparing combines tested in different years. In some crops, workrates were reduced by bunchy and sunken windrows, muddy or rough ground, irregular shaped fields and driving the combine empty to unload grain at a central location. During the 1978 harvest, average workrates varied from 10.2 t/h in 4.3 t/ha Glenlea wheat to 3.4 t/h in 2.0 t/ha Rodney oats.

Maximum Feedrate: The workrates given in TABLE 3 represent average workrates at acceptable loss levels. In most fields, grain losses were still acceptable when the engine was operated near its power limit. In most heavy crops the maximum acceptable feedrate was limited by pickup-to-auger feeding performance, feeder capacity or engine power while in light crops the maximum feedrate was limited by pickup performance.

TABLE 3. Average Workrates

Crop	Variety	Average Yield t/ha	Average Speed km/h	Average Workrate ha/h	Average Workrate t/h
Barley	Bonanza	3.6	5.7	2.5	9.0
Barley	Klages	2.8	5.9	3.6	10.0
Oats	Rodney	2.0	4.0	1007	3.4
Rapeseed	Midas	1.9	4.8	2.2	4.2
Rapeseed	Regent	1.7	6.4	2.7	4.6
Rye	Sangaste	2.5	5.8	1.4	3.6
Wheat	Canuck	2.6	5.8	1.9	4.9
Wheat	Fielder	2.2	5.5	3.5	7.7
Wheat	Glenlea	4.3	6.4	2.4	10.2
Wheat	Lemhi	2.0	4.8	3.3	6.6
Wheat	Neepawa	3.0	5.4	2.4	7.2
Wheat	Sundance	2.8	5.8	1.9	6.2

Capacity: Combine capacity is the maximum rate at which a combine can harvest a certain crop, at a specified total loss level, when adjusted for optimum performance. Many crop variables affect combine capacity. Crop type and variety, grain and straw yield and local climatic conditions during the growing season all affect the threshing and separating ability of a combine.

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 in a certain crop depend mainly on two factors, the quantity of the straw and chaff being processed and the quantity of grain being processed.

The weight of straw and chaff passing through a combine per unit time is called the MOG feedrate. MOG is an abbreviation for "Material-Other-than-Grain" and represents the weight of all plant material passing through the combine except for the grain or seed.

The weight of grain or seed passing through a combine per unit time is called the Grain Feedrate. The ratio of MOG Feedrate to Grain Feedrate, which is abbreviated as MOG/G, gives an indication of how difficult a certain crop is to separate. For example, if a certain combine is used in two wheat fields of identical grain yield but 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 with the MOG/G ratio when determining combine capacity. MOG/G ratios for prairie wheat crops vary from about 0.5 to 1.5.

Grain losses from a combine are of two main types, unthreshed grain still in the head and threshed grain or seed, which is discharged with the straw or chaff. Unthreshed grain is called cylinder loss. Free grain in the straw and chaff is called separator loss and consists of shoe loss and 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. Combine capacity may also be expressed as the MOG Feedrate at which the engine reaches its power limit if this occurs before the total grain loss reaches 3% of yield.

Capacity of the International Harvester 1460: TABLE 4 presents capacity results for the International Harvester 1460 in five different crops.

MOG Feedrates for a 3% total grain loss varied from 17.4 t/h in 2.20 t/ha Canuck wheat to 8.6 t/h in 3.73 t/ha Bonanza barley. In 2.21 t/ha Lemhi wheat the total grain loss at engine power limit reached only 2.5% of yield at a MOG Feedrate of 17.3 t/h.

GRAIN LOSS CHARACTERISTICS

Grain loss characteristics for the International Harvester 1460 in the five crops described in TABLE 4 are presented in FIGURES 14 to 18.

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

Crop Conditions							Capacity Results			
				Grain Moist.ure						
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
Wheat	Canuck[1]	6.1	2.11	9.9	12.4	1.14	–	–	–	Fig. 14
Wheat	Canuck	7.3	2.20	6.3	11.8	1.10	17.4	15.8	9.8	Fig. 15 & 20
Wheat	Lemhi[2, 3]	11.0	2.21	8.5	13.1	0.90	17.3	19.2	7.9	Fig 16 & 21
Wheat	Neepawa	6.1	4.38	8.9	13.2	1.18	14.8	12.5	4.7	Fig 17 & 22
Barley	Bonanza	6.1	3.73	8.8	13.2	0.82	8.5	10.5	4.8	Fig. 18 & 23

[1]Grain loss greater than 3% of yield at minimum capacity.
[2]Side by side double windrow.
[3]Capacity limited by engine power at total loss less than 3% of yield.

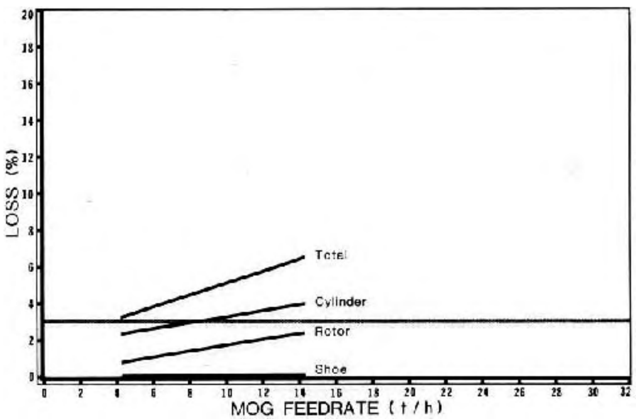

FIGURE 14. Grain Loss in Canuck Wheat.

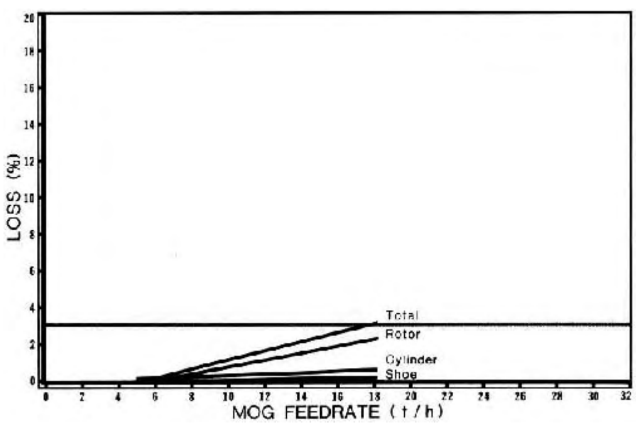

FIGURE 15. Grain Loss in Canuck Wheat.

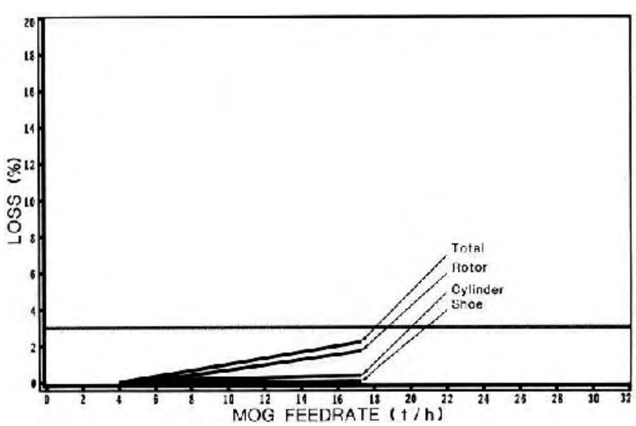

FIGURE 16. Grain Loss in Lemhi Wheat.

Rotor Loss: Rotor losses were low over the full operating range in wheat crops, but became significant in barley crops at high feedrates. With most other combines, straw walker loss is the most significant factor limiting capacity in all grain crops.

The good separating performance of the axial threshing and separating system was attributed to the large threshing and separating concave areas and the number of times the straw passed by the concaves. The exponential increase in grain loss with increased MOG Feedrate, which is common with conventional combines, was present at available power levels in barley, but not in wheat.

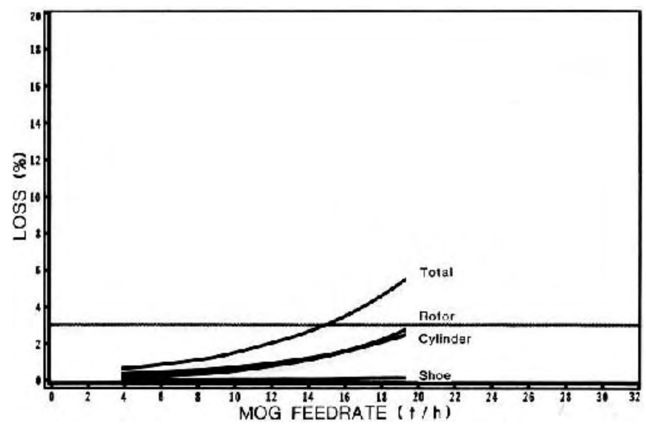

FIGURE 17. Grain Loss in Neepawa Wheat.

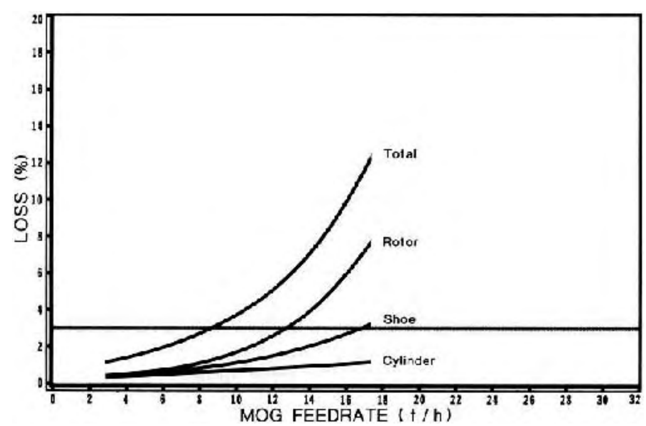

FIGURE 18. Grain Loss in Bonanza Barley.

Shoe Loss: Shoe loss rarely limited combine capacity, but losses became significant in barley crops at high feedrates. High losses could occur on uneven terrain or with improper settings. Shoe loss in a Midas rapeseed crop was acceptable, averaging from 0.75 to 1.5% of yield, but lower shoe losses were seldom attainable due to uneven air, chaff and seed distribution.

Chaff loading and grain losses were higher on the right side of the shoe in heavy Bonanza barley (FIGURE 19), especially at high feedrates. No significant differences were obtained between right and left distribution in wheat crops. Shoe chaff and grain distribution on level ground was affected by rotor speed, concave clearance and feedrate.

Cylinder Loss: Cylinder loss was low in all dry and well matured crops, but became significant if concave clearances were too large in difficult-to-thresh spring wheat (FIGURE 14). Although cylinder loss increased in tough and damp crops, it was usually acceptable. The good threshing performance of the rotor in most crop conditions was attributed to the large number of times the straw passed by the concaves. More complete threshing might occur if the rear separating concaves were bar and wire grate rather than smooth pressed metal.

Body Loss: Slight grain leakage occurred from the junction between the feeder housing and combine body, and from other locations, but was insignificant.

Comparison to Reference Combine: Comparing combine capacities is complex because crop and growing conditions influence combine performance with the result that slightly different capacity characteristics can be expected every year. As an aid in determining relative combine capacities, PAMI 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 PAMI is commonly accepted in the prairie provinces and is described in PAMI evaluation report E0576C. See APPENDIX III for the PAMI reference combine capacity results.

FIGURES 20 to 23 compare the total grain losses of the International Harvester 1460 and the PAMI reference combine in four of the 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, the losses are significantly different. The capacity of the International Harvester 1460 was much greater than the capacity of the reference combine and the International Harvester 1460 had much lower grain losses than the reference combine when operating at the same feedrate.

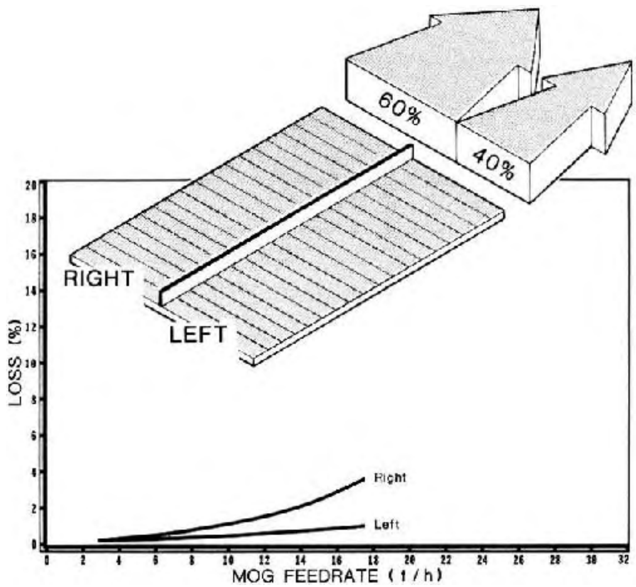

FIGURE 19. Chaff Load and Shoe Loss in Bonanza Barley.

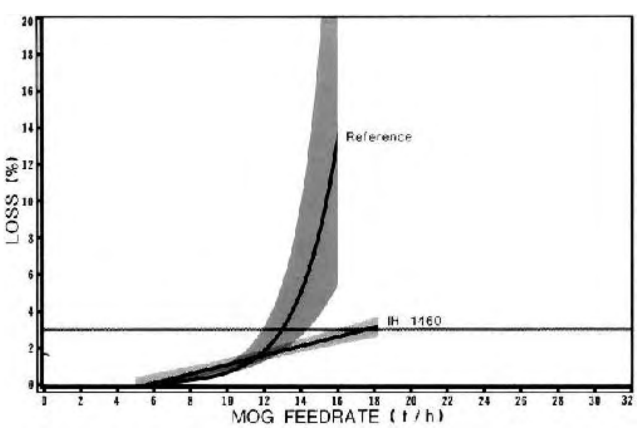

FIGURE 20. Total Grain Losses in Canuck Wheat.

FEEDING AND THRESHING CHARACTERISTICS

Feeding Characteristics: The International Harvester 1460, equipped with a single rotor, did not divide crop flow. The crop was funnelled into a small area to feed the single rotor, restricting capacity, especially in very bunchy crops such as rapeseed. Feeding was uniform in well formed parallel windrows and less uniform in windrows with random straw orientation. Best results were obtained in uniform parallel single windrows. Depending on crop and field conditions, double swathing did not significantly increase combine capacity, but rather increased feeder plugging frequency.

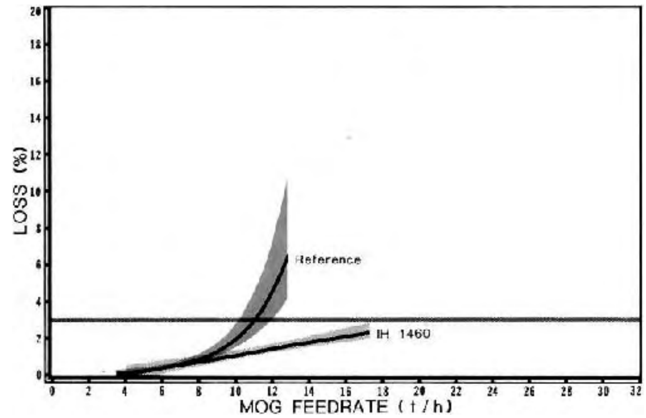

FIGURE 21. Total Grain Losses in Lemhi Wheat.

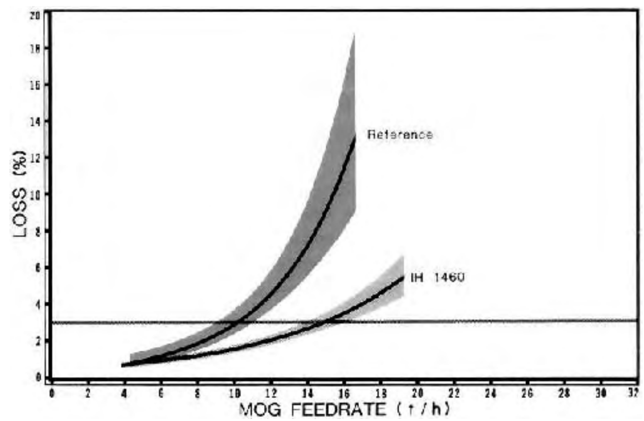

FIGURE 22. Total Grain Losses in Neepawa Wheat.

Vibration: When operating near engine power limit at high feedrates, a shuddering noise and low frequency vibration were apparent. This behaviour was intermittent, originating from the rotor assembly, and could have been caused by rotor vibration. It was avoided by operating at a feedrate just below its occurrence.

OPERATOR SAFETY

The operator's manuals emphasized operator safety.

The International Harvester 1460 had adequate warning decals. It was also equipped with a slow moving vehicle sign, warning lights and rear view mirrors for road transport. It was well shielded, giving good protection from moving parts. Most shields were easy to remove and install. Although the upper body shrouding was aesthetically pleasing, it made repair difficult.

The combine was equipped with a header lock and its proper use was emphasized in the combine and header manuals. The header lock must be used when working beneath or around the header.

A rocking wrench and hub were provided for unplugging the feeder auger. This improved operator safety as it was unnecessary to enter the header to unplug the table auger.

The unloading auger should be swung back against the side of the combine after unloading or when transporting.

When using the slug wrench to unplug the rotor, the engine should be shut off and the separator clutch disengaged. The rotor slug wrench should be removed and side inspection doors replaced before the engine is started and the separator engaged.

The feeder and separator drives, actuated hydraulically, were electrically controlled with unguarded toggle switches. It is recommended that the manufacturer consider guarding the switches to prevent accidental machine engagement.

If recommended safety procedures were followed, all adjustments could be safely made. The operator must be cautioned about the possibility of head injury when entering or leaving the cab. A fire extinguisher should be carried on the combine at all times.

Operator's Manual: Operator's manuals were provided for both the combine and the header.

The operator's manuals were clearly written, well illustrated and contained much useful information on servicing, adjustments and suggested settings in various crops. It is recommended that the manufacturer supply initial settings for rapeseed.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the International Harvester 1460 during 127 hours of operation while combining about 293 ha. The intent of the test was evaluation of functional performance. The following failures represent those, which occurred during functional testing. An extended durability evaluation was not conducted.

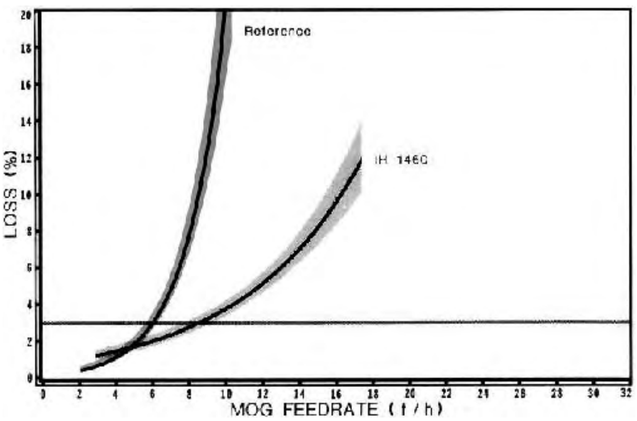

FIGURE 23. Total Grain Losses in Bonanza Barley.

TABLE 5. Mechanical History

Item	Operating Hours	Field Area ha
Drives		
-The CC255 drive belt on the right combine side failed at	47	93
-The rotor variable speed adjustment drive chain separated and was replaced at	108	231
Hydraulics		
-A priority valve stuck due to contamination, causing the steering system to lock at	beginning of test	
-this recurred at	3	5
Miscellaneous		
-The fan speed indicator wheel moved away from its pickup and was re-secured at	13	
-Digital tachometer nixie tubes failed requiring module replacement at	32	52
-The alternator quit charging due to foreign material contamination, necessitating cleaning at	75, 116	116, 253
-The fuel tank leaked	throughout the test	
-Concave support pin deformation reached 6 mm by	end of test	

DISCUSSION OF MECHANICAL PROBLEMS

Concave: The adjustable threshing concave assembly is supported by two 12.7 mm pins. Concave creep due to pin deformation (FIGURE 24) reached 6 mm by the end of the test. It is recommended that the manufacturer consider modifications to the concave support pins to prevent concave creep.

Alternator: The alternator quit charging on two occasions due to foreign material accumulation. It is recommended that the manufacturer consider modifying the alternator to prevent foreign material entry.

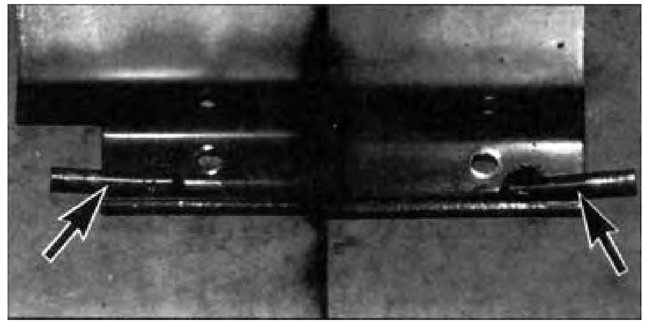

FIGURE 24. Concave Support Pin Deformation.

APPENDIX I
SPECIFICATIONS

MAKE:	International Harvester Self-Propelled Combine
MODEL:	1460
SERIAL NUMBER:	Header 148007526048, Combine 1700189U002063, Engine 436TF2U060402
MANUFACTURER:	International Harvester Company East Moline, Illinois 61244
WINDROW PICKUP:	
--type	belt
--pickup width	3350 mm
--number of belts	6
--teeth per belt	56
--type of teeth	nylon
--number of rollers	2
--height control	castor wheels
--speed control	hydrostatic
--speed range	0 to 425 rpm
HEADER:	
--type	centre feed
--width	3960 mm
--auger diameter	508 mm
--feeder conveyor	2 roller chains, undershot slatted conveyor
--conveyor speed	2.54 m/s
--range of picking height	-405 to 1040 mm
--number of lift cylinders	2
--raising time	5 s
--lowering time	adjustable
--options	header cutting equipment, header end sheet deflectors, auger flight extensions, grain header bottom shields, perforated feeder bottom, header height control
STONE PROTECTION:	
--type	reinforced feeder drum; travel limited by 4 position stop
--ejection	hand removal after reversing feeder conveyor
ROTOR:	
--crop flow	axial
--number of rotors	1
--type	parallel and spiral rasp bars front portion; 3 parallel smooth bars rear portion
--diameter	
-tube	493 mm
-feeding portion	860 to 542 mm
-threshing portion	608 mm
-separating portion	544 mm
--length	
-feeding portion	515 mm
-threshing portion	1100 mm
-separating portion	1120 mm
--total	2735 mm
--drive	electrically controlled variable pitch belt through 2 speed gearbox
--speeds	
-low range	330 to 690 rpm
-high range	640 to 1320 rpm
CONCAVES (THRESHING):	
--number	1 consisting of three removable portions
--type	bar and wire grate
--number of bars	20
--configuration	
-narrow spaced	19 intervals with 4.8 mm wires and 6 mm spaces
-wide spaced	19 intervals with 6.4 mm wires and 15 mm spaces
--area	0.762 m²
--wrap	118°
--grain delivery to shoe	4 auger conveyors
--options	wide spaced concaves

CONCAVES (SEPARATING):

--number	1
--type	perforated formed metal
--area	1.112 m²
--wrap	202°
--grain delivery to shoe	4 auger conveyors

THRESHING AND SEPARATING CHAMBER:

--number of spirals	12
--pitch of spirals	22°

BACK BEATER:

--type	4 wing box
--speed	820 rpm

SHOE:

--type	opposed action
--speed	280 rpm
--chaffer sieve	adjustable lip, 1.35 m² with 55 mm throw
--chaffer extension	adjustable lip, 0.28 m²
--clean grain sieve	adjustable lip, 1.35 m² with 31 mm throw
--options	perforated elevator doors, troughs and extensions, miscellaneous sieves

CLEANING FAN:

--type	6 blade undershot
--diameter	509 mm
--width	855 mm
--drive wheel	controlled variable pitch belt
--speed range	360 to 1010 rpm
--options	air intake screens

ELEVATORS:

--type	roller chain with rubber flights, top delivery
--clean grain (top drive)	203 x 203 mm
--tailings (top drive)	152 x 203 mm

GRAIN TANK:

--capacity	6.34 m³
--unloading time	112 s
--options	perforated unloading tube

STRAW SPREADER:

--number of spreaders	2
--type	steel hub with 6 rubber bats
--speed	250 rpm

ENGINE:

--make and model	International DT-436
--type	4 stroke turbocharged diesel
--number of cylinders	6
--displacement	7.14 L
--governed speed (full throttle)	2700 rpm
--manufacturer's rating at 2500 rpm	126.8 kW
--fuel tank capacity	350 L
--options	pre-cleaner, coolant filter conditioner, block heater, rotary air screen discharge chute

CLUTCHES:

--header and separator	electro-hydraulic controlling V belt tightener
--unloading auger	V-belt
--traction drive	hydraulic valve (foot-n-inch pedal)

NUMBER OF CHAIN DRIVES: 11

NUMBER OF BELT DRIVES: 13

NUMBER OF GEAR BOXES: 4

NUMBER OF PRELUBRICATED BEARINGS: 69

LUBRICATION POINTS:

--10 h lubrication	5
--50 h lubrication	22
--100 h lubrication	6
--200 h lubrication	3
--500 h lubrication	9

TIRES:

--front	23.1 x 26 R 1, 10-ply
--rear	10.0 x 16, 6-ply

TRACTION DRIVE:

--type	hydrostatic
--speed ranges (23.1 x 26 R1 tires)	
-1st gear	0 to 5.9 km/h
-2nd gear	0 to 10.7 km/h
-3rd gear	0 to 28.2 km/h

OVERALL DIMENSIONS:

--wheel tread (front)	760 mm
--wheel tread (rear)	1840 mm
--wheel base	3480 mm
--transport height	3960 mm
--transport length	8310 mm
--transport width	4650 mm
--field height	4160 mm
--field length	8270 mm
--field width	7380 mm
--unloader discharge height	3770 mm
--unloader clearance height	3580 mm
--unloader reach	2730 mm
--turning radius	
-left	6200 mm
-right	6500 mm
--clearance radius	
-left	7320 mm
-right	9610 mm

MASS: (with empty grain tank)

--right front wheel	3130 kg
--left front wheel	3460 kg
--right rear wheel	1170 kg
--left rear wheel	1170 kg
TOTAL	8930 kg

ADDITIONAL OPTIONS:

--main axle extensions, drive wheel spacers, operator's platform extensions, pivoting ladder attachment, weight bracket, windshield wiper.

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations, for the capacity results shown in FIGURES 14 to 18 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 14 to 18 while crop conditions are presented in TABLE 4.

TABLE 6. Regression Equations

Crop - Variety	Fig. No.	Regression Equations	Simple Correlation Coefficient	Sample Size
Wheat - Canuck	14	$C = 1.70 + 0.16F$ $S = 0.05 + 0.006F$ $R = 0.16 + 0.16F$	0.84 0.59 0.93	7
Wheat - Canuck	15	$C = -0.08 + 0.04F$ $S = -0.13 + 0.02F$ $R = -1.00 + 0.19F$	0.80 0.90 0.95	8
Wheat - Lemhi	16	$C = 0.04 + 0.02F$ $S = -0.05 + 0.01F$ $R = -0.16 + 0.14F$	0.84 0.70 0.94	8
Wheat - Neepawa	17	$\ln C = -1.39 + 0.12F$ $S = 0.02 + 0.01F$ $\ln R = -2.04 + 0.16F$	0.99 0.67 0.98	9
Barley - Bonanza	18	$C = 0.18 + 0.06F$ $\ln S = -1.12 + 0.014F$ $\ln R = -1.42 + 0.20F$	0.86 0.94 0.98	11

[1]Significant at P O0.05
[2]Significant at P O0.01

APPENDIX III
PAMI REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 25 and 26 present capacity results for the PAMI reference combine in wheat and barley crops harvested from 1976 to 1978.

In 1976, after a warm and dry growing season, capacity tests were conducted in crops harvested soon after windrowing, with the windrows receiving little or no rain. In 1977, after a cool and moist growing season, tests were conducted in crops harvested long after windrowing and subjected to many wetting and drying cycles. In 1978, growing and harvesting conditions were quite similar to 1977, though the windrows were not subjected to as many wetting and drying cycles,

FIGURE 25 shows large capacity differences in Neepawa wheat for the three years. Although grain moisture contents were similar in all three years, straw moisture content was slightly lower in 1978 than in the other two years, Cylinder losses and MOG/G ratios were highest in 1976, intermediate in 1978, and lowest in 1977, with corresponding low capacity in 1976, intermediate capacity in 1978 and high capacity in 1977.

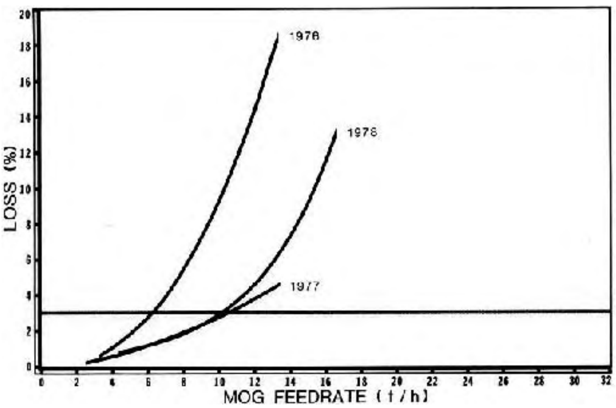

FIGURE 25. Total Grain Losses for the PAMI Reference Combine in Neepawa Wheat.

FIGURE 26 also shows differences in capacities in Bonanza barley. Grain moisture contents were similar but straw moisture contents were quite different. The high straw moisture content in 1977 Bonanza barley crop was not indicative of the physical properties of the straw, which was green but not damp. The lower straw moisture content of the 1978 crop resulted in more straw break-up and heavier shoe loading, causing higher straw walker and shoe losses than in 1977 (the lower 1978 MOG/G ratio influenced losses less than straw break-up). Capacity was lowest in 1976 due to the highest straw walker losses, caused by the high MOG/G ratio and straw break-up.

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

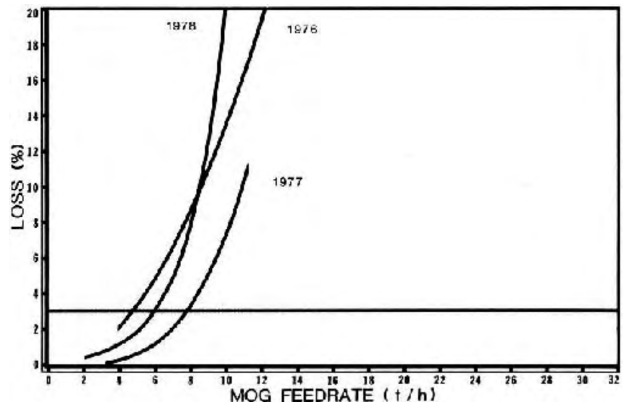

FIGURE 26. Total Grain Losses for the PAMI Reference Combine in Bonanza Barley.

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

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
1976	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	9.2	13.9	1.15	10.8	9.4	3.6	Fig. 25
	Barley	Bonanza	6.1	4.06	7.7	13.5	0.66	8.1	9.0	3.6	Fig. 26
1977	Wheat	Neepawa	6.1	3.97	13.4	14.6	0.79	11.1	14.1	5.8	Fig. 25
	Barley	Bonanza	7.3	4.74	25.7	14.6	0.84	7.9	9.4	2.7	Fig 26
1978	Wheat	Neepawa	5.5	3.78	dry to tough	14.7	1.29	7.1	5.5	3.6	Fig. 25
	Barley	Bonanza	7.3	3.18	dry to tough	14.6	0.96	4.8	5.0	2.2	Fig 26

1. Side by Side Double Windrow.

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

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

APPENDIX V
METRIC UNITS

In keeping with the Canadian metric conversion program, this report has been prepared in SI units. For comparative purposes, the following conversions may be used:

1 kilometre/hour (km/h)	= 0.62 miles/hour (mph)
1 hectare (ha)	= 2.47 acres (ac)
1 kilogram (kg)	= 2.2 pounds mass (lb)
1 tonne (t)	= 2204.6 pounds (lb)
1 tonne/hectare (t/ha)	= 0.45 ton/acre (ton/ac)
1 tonne/hour (t/h)	= 36.75 pounds/minute (lb/min)
1000 millimetres (mm) = 1 metre (m)	= 39.37 inches (in)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 litre/hour (L/h)	= 0.22 Imperial gallons/hour (gal/h)

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