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Evaluation Report 143

Massey Ferguson 760 Self-Propelled Combine

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI

PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

MASSEY FERGUSON 760 SELF-PROPELLED COMBINE

MANUFACTURER:
Massey Ferguson Industries Ltd.
915 King Street West
Toronto, Ontario
M6K 1E3

DISTRIBUTOR:
Massey Ferguson Industries Ltd.
Box 1340, Station T
Calgary, Alberta
T2C 1G3

RETAIL PRICE:
$67,349.00, May, 1979, f.o.b. Humboldt, with 4.0 m header, 3.2 m Melroe pickup, straw chopper, 8.85 L V8 diesel engine, hour meter, ether starting assist, air cleaner restriction indicator and pre-cleaner, adjustable rear axle, hydrostatic ground drive, high inertia cylinder, double range cylinder drive, straw walker risers, 8 mm round hole screen, electrically controlled variable speed pickup drive, unloader spout boot, field lighting kit, tool box, cab with air conditioning, heater and mirror.

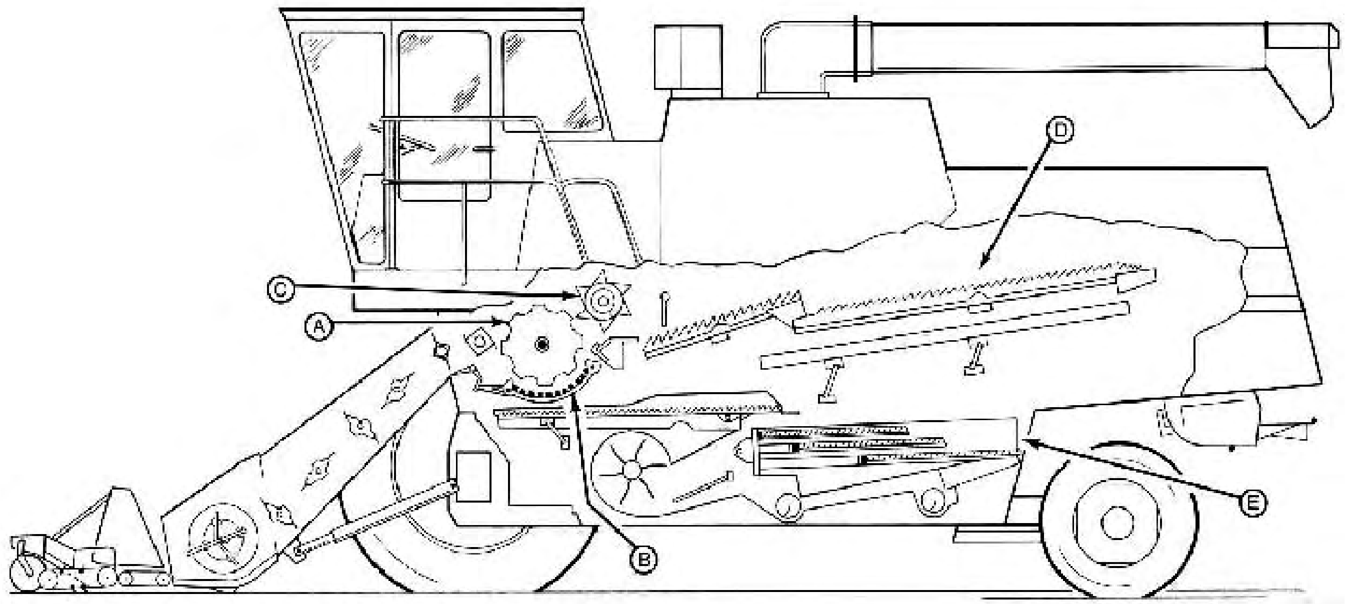

FIGURE 1. Massey Ferguson 760: (A) Cylinder, (B) Concave, (C) Back Beater, (D) Straw Walkers, (E) Shoe.

SUMMARY AND CONCLUSIONS

Functional performance of the Massey Ferguson 760 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 15 t/h (551 lb/min) in a field of 2.53 t/ha (38 bu/ac) Canuck wheat to 6.9 t/h (254 lb/min) in 3.93 t/ha (73 bu/ac) Bonanza barley. The capacity of the Massey Ferguson 760 was greater than the capacity of the PAMI reference combine for a similar total grain loss. Straw walker loss limited capacity in most crops. A reduction in grain loss over the straw walkers would have permitted higher combining rates. In easy-to-thresh crops on level ground, cylinder and shoe losses usually were insignificant.

The engine had ample power for all conditions. Fuel consumption varied from 18 to 27 L/h (4 to 6 gal/h). The cyclone radiator air intake, though preventing radiator plugging, itself plugged on several occasions causing engine overheating. Engine starting was satisfactory. If ambient temperature dropped below +5°C, the engine ether starting assist was needed.

The steering and braking systems were very good. By using the individual wheel brakes it was possible to pick most sharp corners formed by self-propelled windrowers. Instruments and most controls were conveniently positioned. Most controls were responsive. The cab was adequately pressurized and relatively dust free, but the air conditioning and heating systems should be modified to improve operator comfort. Sound level at the operator's station was about 88 dBA.

Header visibility was good both in daytime, and at night, although the right cab corner post restricted windrow visibility. Grain level visibility was satisfactory. Rear visibility was restricted. Rear view mirrors were needed for road transport. Normal caution was required when operating the Massey Ferguson 760 at maximum transport speed of 24.3 km/h (15.2 mph).

The Massey Ferguson 760 was quite easy to adjust for specific field conditions. Adjustment would have been easier if return tailings could have been inspected. The straw chopper and rethresher monitoring system was helpful by warning the operator of malfunction. Ease of servicing was good.

The table auger feeder and cylinder had very good capacity in dry grain crops and plugging was infrequent. Capacity was reduced in heavy bunchy rapeseed and in damp grain crops due to choking and plugging of the paddle feeder housing.

Cylinder plugging seldom occurred. Cylinder access was inconvenient. The stone trap stopped most stones before they entered the cylinder and was fairly easy to clean. The Melroe pickup had excellent feeding characteristics, delivering the crop beneath the table auger. No serious safety hazards were noticed when operating 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. No major durability problems occurred during the test, although an engine compartment fire occurred due to chaff accumulation and radiator air intake plugging.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifications to improve windrow visibility from the operator's cab.

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

2. Modifications to the air conditioning and heating systems to improve operator comfort.
3. Modifications to the radiator cyclone air intake system to reduce plugging and fire hazards.
4. Providing a rocking hub on the table auger drive to facilitate unplugging.
5. Modifications to reduce header drop hesitation.
6. Modifications to the shoe to eliminate spearing.
7. Modifications to simplify shield removal and replacement.
8. Revising the operator's manual to provide a clearer lubrication procedure and new initial settings for rapeseed.

Chief Engineer E. 0. Nyborg
Senior Engineer L. G. Smith
Project Engineer P. D. Wrubleski

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. 1979 machines have as standard equipment cabs with narrower front corner posts for better vision.
2. A new air conditioning system and improved heater location are standard on 1979 production.
3. 1979 machines incorporate air driven rotating vanes to reduce chaff plugging. An improved suction tube, to reduce plugging, and an improved inlet screen, to reduce straw ingress, will be incorporated soon.
4. This will be given active consideration for early incorporation.
5. 1979 machines have an increased capacity hydraulic pump for more positive header lift. Header drop hesitation has not been a customer complaint, however, we will investigate this.
6. Investigation and consideration of this recommendation will be pursued.
7. Within regulatory and prudence guidelines, action is already under way to simplify shielding.
8. Operator manual improvements as cited will be incorporated in the next edition.

GENERAL DESCRIPTION

The Massey Ferguson 760 is a self-propelled combine with a transverse-mounted, tangential threshing cylinder and straw walkers. Threshing and initial separation occur at the cylinder and concave while final separation of grain from straw is accomplished with the straw walkers. A cleaning shoe is used, with return tailings delivered to a rethresher.

The test machine was equipped with a 104 kW, eight cylinder, Perkins diesel engine; a 4.0 m header; a 3.2 m Melroe 351 pickup and the optional accessories listed on PAGE 2, including a pressurized operator's cab.

Traction drive is through a four speed transmission and an optional hydrostatic drive system. The Massey Ferguson 760 is equipped with power steering and hydraulic wheel brakes.

The separator and unloading auger drives are controlled through over-centre belt tighteners while the header drive is controlled with an optional electromagnetic clutch.

Hydraulic levers control the ground speed and unloading auger swing while header height is controlled electro-hydraulically. Concave clearance as well as pickup and cylinder speeds can be adjusted on-the-go from the operator's platform. Fan speed is adjusted with a crank operated variable speed belt drive, while fan blast is directed with an adjustable windboard. The sieves 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 Massey Ferguson 760 was operated in a variety of Saskatchewan and Alberta crops (TABLES 1 and 2) for 109 hours while harvesting about 270 ha. 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 PAMI reference combine.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield t/ha	Swath Width m	Hours	Field Area ha
Barley	Bonanza	2.6	4.6 to 7.3	11.0	29
Barley	Klages	2.5	7.3	7.5	19
Rapeseed	Midas	1.7	4.6 to 7.3	9.0	21
Rapeseed	Regent	1.6	6.1	6.0	20
Rye	Sangaste	2.3	6.1	10.5	22
Wheat	Canuck	2.6	5.5 to 7.3	11.5	27
Wheat	Fielder	2.6	11.0	4.5	16
Wheat	Lemhi	2.0	11.0	1.5	7
Wheat	Neepawa	3.0	6.1	12.5	31
Wheat	Sundance	2.8	5.5 to 6.1	21.0	52
Wheat	Wascana	2.3	7.3	13.5	26
Total				109	270

TABLE 2. Operation In Stony Fields

Field Conditions	Hours	Field Area ha
Stone Free	37	63
Occasional Stones	66	167
Moderately Stony	6	20
Total	109	270

RESULTS AND DISCUSSION

EASE OF OPERATION

Operator Location: The test machine was equipped with an optional operator's cab. The cab was positioned ahead of the grain tank, left-of-centre, giving good visibility to the left, front and right. Visibility to the rear was nearly 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. Grain tank level was difficult to view from the operator's cab, while grain and return tailings could not be sampled from the operator's seat.

The right cab corner post obstructed the operator's view of the incoming windrow (FIGURE 2) and it is recommended that the manufacturer consider modifications to improve visibility.

FIGURE 2. Operator's View of the Windrow.

The operator's seat was comfortable and had an adequate range of adjustment. Steering column adjustment was satisfactory. 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. The optional air conditioning system provided suitable cab temperatures under hot operating conditions, but the cooling vents directed air on the operator rather than throughout the cab. The heater was located near the floor to the right of the operator and did not evenly heat the cab. It is recommended that the manufacturer consider modifications to the air conditioning and heating systems to improve operator comfort.

Total noise at operator ear level was about 88 dBA.

Controls: The control arrangement is shown in FIGURE 3. Though most controls were responsive, the hydrostatic ground speed control lever was uncomfortable to operate as it was not hand contoured. The cylinder speed adjusting crank was very difficult to turn with one hand, due to its location. When engaged, the combination auger unloading-swing lever was too low for the operator to comfortably reach. Though the header lift was quick enough to suit all conditions and the header drop rate was adjustable, the header drop had an inherent delay. It is recommended that the manufacturer consider modifications to reduce header drop hesitation.

Steering: Steering and maneuverability were very good. The power steering was smooth and responsive. The turning radius was about 7.3 m and by using the individual wheel brakes it was possible to pick most corners formed by self-propelled windrowers. The wheel brakes were very 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 3) included gauges for cylinder speed, engine oil pressure, coolant temperature, battery charging and hydraulic oil temperature. The coolant temperature gauge was equipped with a high temperature shutoff and safety reset button. Warning lights and a buzzer were provided for the parking brake, rethresher and straw chopper (FIGURE 4).

Lights: The Massey Ferguson 760 was equipped with four front lights and two rear lights. Header lighting, long range front lighting and lighting for the grain tank, unloading auger and area behind the combine all were good. However, one light to the right of the cab and another to the left of the cab caused glare in the operator's eyes.

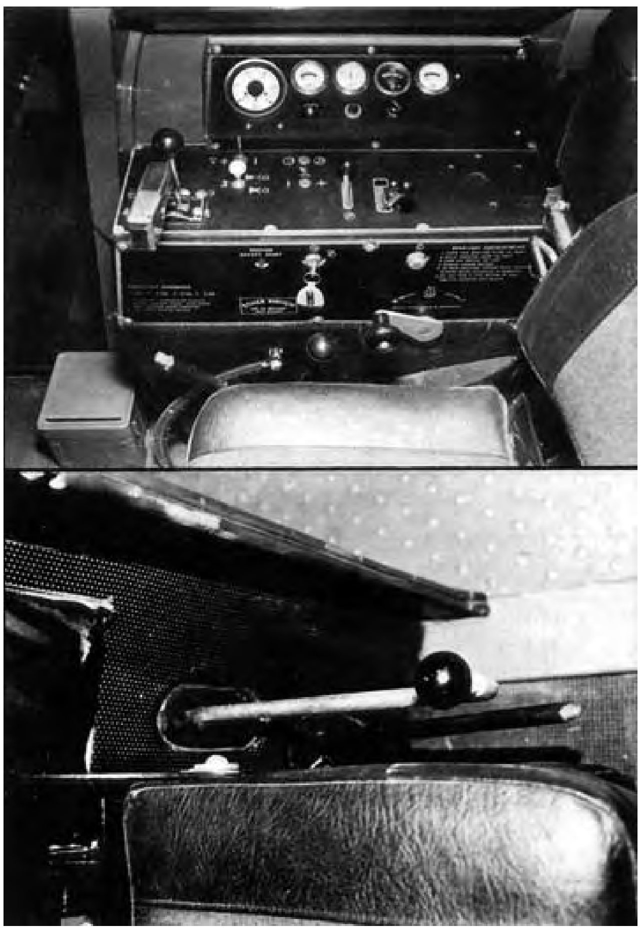

FIGURE 3. Control and Instrument Layout.

Engine: The engine had ample power for all operating conditions. Average fuel consumption varied from 18 to 27 L/h. The engine was located to the right of the operator's cab and was quite accessible.

The cyclone radiator air intake was effective in preventing radiator plugging in normal conditions, but caused engine overheating under certain conditions. On one occasion, fine thistle down plugged the radiator inlet screen, while at other times, long straws plugged the suction tube that exhausted chaff from the cyclone. Although thistle down was easily removed, the vacuum tube was difficult to clean as the grain tank had to be partially emptied and the tube removed. The cyclone exhausted chaff into the engine compartment. On one occasion, this caused a fire, when the cyclone air intake (FIGURE 5) plugged, overheating the engine, igniting chaff build-up. It is recommended that the manufacturer modify the radiator air intake to eliminate plugging and reduce fire hazards.

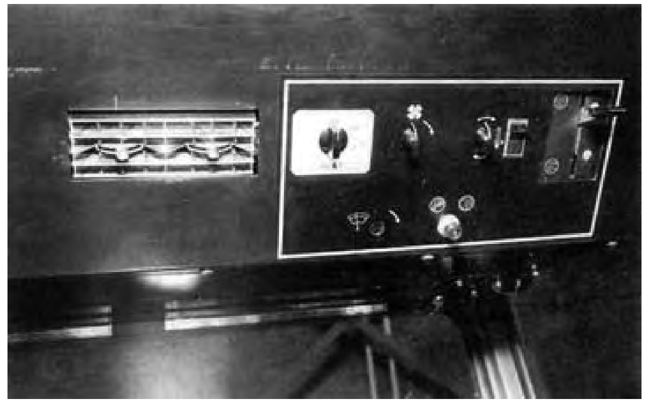

FIGURE 4. Warning System and Environmental Controls.

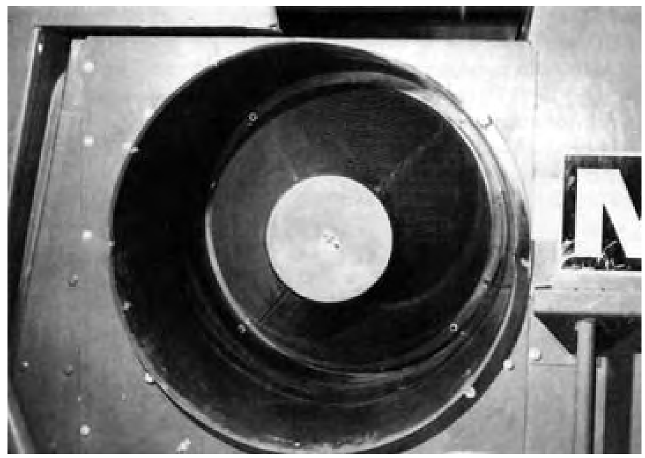

FIGURE 5. Cyclone Radiator Air Intake with Stator Removed.

The engine air intake used a screen pre-cleaner, a centrifugal bowl cleaner and two dry filters. The dry filter element required infrequent servicing if the pre-cleaner bowl was emptied before it completely filled. A restriction warning was provided to indicate filter servicing.

The engine started easily. Engaging the excess fuel button usually facilitated starting. If ambient temperature dropped below +5° C, the ether starting aid had to be used to start the cold engine.

The batteries were inconveniently located beneath the radiator air intake housing, making boosting and battery servicing difficult.

Stability: The Massey Ferguson 760 was very stable, even with a full grain tank. The centre of gravity, with a three-quarters full grain tank was about 1990 mm above ground, 1130 mm behind the drive wheels and 170 mm left of the combine centre line. Normal care had to be used when turning corners on hillsides.

Normal caution was required when operating the Massey Ferguson 760 at maximum transport speed of 24.3 km/h.

Grain Tank: The grain tank held 6.11 m^3 of wheat. Unloading a full hopper of dry wheat took 126 seconds. The grain tank filled evenly in all crops.

The unloading auger had sufficient clearance and reach for easy unloading on-the-go. Erratic discharge of the unloading auger caused problems in high wind. A different discharge boot design to reduce scatter in wind, would be beneficial.

Straw Chopper: The optional straw chopper attachment performed well in most crops although the knives could not be fully engaged in some crops as belt slippage occurred. Maximum spreading width varied from 4 to 5 m, depending on straw and wind conditions, and spreading was inadequate for swath widths greater than 5.5 m. If the straw was to be windrowed, the chopper moved easily rearwards on railings.

FIGURE 6. Spreading of Chopped Straw.

Plugging: The table auger was quite aggressive in dry grain crops and plugging was infrequent when operating at normal feedrates. In heavy, bunchy rapeseed and damp grain crops, choking and plugging of the table auger occurred more frequently. Unplugging was difficult because of shielding by the pickup windguard. It is recommended that the manufacturer provide a rocking hub on the table auger drive to facilitate unplugging.

Improved performance in bunchy rapeseed was obtained by removing the auger flight extensions. This reduced the windrow concentration at the centre of the feeder housing. In other heavy strawed crops, such as fall rye, the flightings were also removed to reduce plugging. Performance in all crops might be satisfactory if lower wrap auger flight extensions were included with the combine.
Though the paddle feeder (FIGURE 7) had high capacity in most crops, plugging occurred more frequently in rapeseed and wild oat infested crops. Unplugging of the paddle feeder housing was extremely difficult as every second paddle depressed crop against the feeder house bottom. A plugged feeder housing usually took about 30 minutes to unplug. Since the table auger and feeder housing slip clutches are in parallel rather than in series as on most combines, plugging was more severe. For example, when the feeder housing plugged first, the table auger force fed the feeder housing until the auger also plugged. If the two clutches were installed in series, the severity of plugging would likely be reduced.

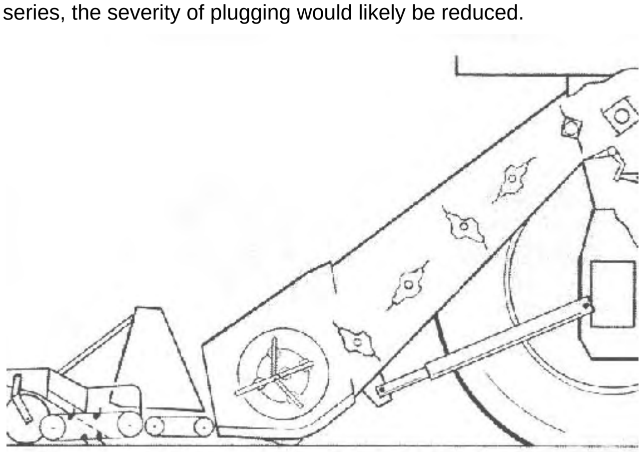

FIGURE 7. Paddle Feeder.

The cylinder was very aggressive and plugging seldom occurred. The cylinder could usually be unplugged in fifteen minutes by lowering the rear of the concave using the special eccentric provided, switching the cylinder gearbox to low gear and power unplugging. If the rear eccentric was not used unplugging usually took forty-five minutes. Cylinder access was through a door in the engine compartment and was very inconvenient. Backfeeding occurred in bunchy rapeseed windrows and when encountering damp wads of wild oat straw.

As with most combines dust and chaff collected inside the cylinder rasp bars, causing cylinder imbalance. The inside of the rasp bars occasionally had to be cleaned to prevent cylinder vibration.

Straw and chaff accumulated between the clean grain pan and the bottom sieve immediately in front of the return elevator trough and had to be removed periodically. Spearing of straw in the shoe occurred in fall rye, winter and durum wheat (FIGURE 8) and straw removal was time consuming. It is recommended that the manufacturer consider modifications to the shoe to eliminate spearing.

FIGURE 8. Spearing in Shoe.

Stone Trap: The Massey Ferguson 760 was equipped with a stone trap in front of the cylinder below the front beater, which emptied onto the ground. The stone trap was quite effective, capturing most roots or stones before they entered the cylinder.

Pickup: The Massey Ferguson 760 was equipped with a 3.2 m Melroe 351 pickup. The pickup had excellent feeding characteristics, delivering the crop beneath the table auger in all conditions. In bunchy rapeseed crops, the windguard had to be removed to prevent plugging between the windguard and pickup apron. Pickup speed, which could be varied electrically from the operator's seat, was adequate for most crops.

Machine Cleaning: As with most combines, completely cleaning the Massey Ferguson 760 for combining seed grain was laborious and time-consuming. The stone trap was easy to dump and clean, but the grain pan beneath the concave was very difficult to clean. The sieves were easy to remove for cleaning of the tailings and clean grain augers. The grain tank was very difficult to clean, while the cross-over auger connecting the saddle tanks was inaccessible. Entering and working in the grain tank was hazardous.

Lubrication: The Massey Ferguson 760 has 45 pressure grease fittings. Twenty-seven needed greasing every 10 hours, thirteen needed greasing every 50 hours, one needed greasing every 100 hours and four required greasing annually. Lubrication banks greatly facilitated the ease of lubrication. Four fittings required component rotation to facilitate lubrication and some fittings were located behind shields, not conveniently removable. The intermediate pulley on the hydrostatic drive system was nearly impossible to lubricate and the fitting on the straw walker grain pan crank was difficult to reach due to chaff accumulation under the accompanying shield.

Engine and hydraulic oil levels required daily checking. Though the oil was easy to drain, the engine oil filters, located behind the engine, were very difficult to change. The hydraulic and hydrostatic systems used a common reservoir, which was easy to fill.

EASE OF ADJUSTMENT

Field Adjustments: The Massey Ferguson 760 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 Massey Ferguson 760 had a single segment concave. The concave could be levelled with two draw bolts at the rear and a single levelling eccentric at the front. Front and rear concave clearances could be gauged through side inspection holes. Access to the front left inspection hole was very difficult. The operator should periodically check initial concave clearances over the width of the concave as clearances at the outside edges of the cylinder bars may be smaller, giving erroneous settings. Suitable initial concave settings, with the operator's station control lever in the fifth notch, were 8 mm at the leading bar and 3 mm at the trailing bar.

Once the concave has been initially set, clearances could be adjusted with a lever in the operator's cab. The control linkage was designed so that the leading concave bar opened faster than the trailing bar. Leading bar clearances could be varied from 4 to 25 mm while trailing bar clearances could be varied from 1 to 6 mm.

Care must be taken to avoid lowering the lever to the completely open position as the linkage may jam and prevent raising of the concave. In addition, a pinch point existed between the concave lever and the heater when the lever was set to any position greater than number 11.

Suitable concave control level quadrant settings were notch number 3 in hard spring wheat, number 5 in barley, fall rye and winter wheat and number 11 in rapeseed. Concave filler bars were not needed in any crop, as the first two openings of the concave are permanently blanked.

Cylinder Adjustment: The cylinder was equipped with a tachometer and a variable speed drive, adjustable from the operator's seat with a hand crank assembly (FIGURE 3). The variable drive provided speeds from 340 to 760 rpm in low range and 550 to 1210 rpm in high range. This range was adequate for all prairie crops encountered during the test.

Suitable cylinder speeds were frown 900 to 1050 rpm in hard spring and durum wheat, 800 to 900 rpm in fall rye, winter wheat and soft spring wheat, 750 to 850 rpm in barley and 400 to 600 rpm in rapeseed.

Grain damage varied from 2 to 4% in Lemhi wheat and from 2.5 to 6% in Neepawa wheat (FIGURE 9). Grain damage was about 2% in Canuck wheat and Bonanza barley (FIGURE 9) and 1 to 2% in Regent rapeseed.

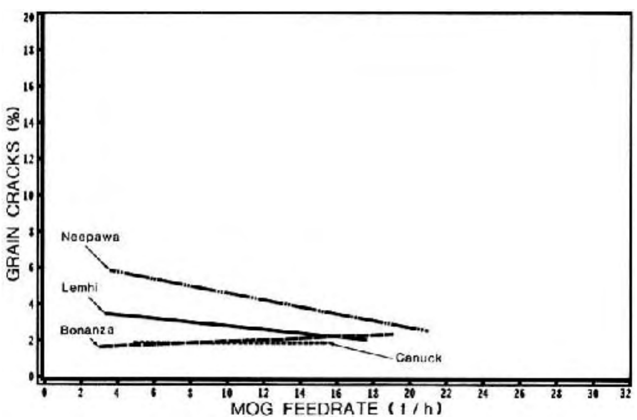

FIGURE 9. Grain Damage.

The cylinder rasp bars were in good condition at the end of the test, showing negligible wear.

Shoe Adjustment: The shoe was convenient to adjust. Fan blast was varied with a crank operated variable speed drive and directed with a windboard (FIGURE 10). The windboard was most effective in positions 5 and 6, directing air to the front of the cascade cleaning shoe.

The triple cascade shoe (FIGURE 11) contained five adjustable sieves and one fixed 8 mm round hole screen. The five adjustable sieves were readily accessible from the rear of the combine.

Return tailings were delivered to a rethresher (FIGURE 12), which discharged to the straw walker grain pan. The rethresher concave packed with soil and plant residue during normal operation, and required frequent cleaning. To determine the grain damage caused by the rethresher, tests were run in Neepawa wheat with the rethresher operative and inoperative (FIGURE 13). Grain damage was slightly higher with the rethresher operative.

The shoe was easy to set and performed well in most crops. As discussed previously, spearing occurred in fall rye, winter and durum wheat.

Total dockage in the grain tank, including cracks, white caps and chaff usually varied from 0.3 to 2% when properly adjusted. It was best to set the shoe for optimum performance in the heavy windrow section and to increase feedrate in light windrow sections to maintain uniform shoe load.

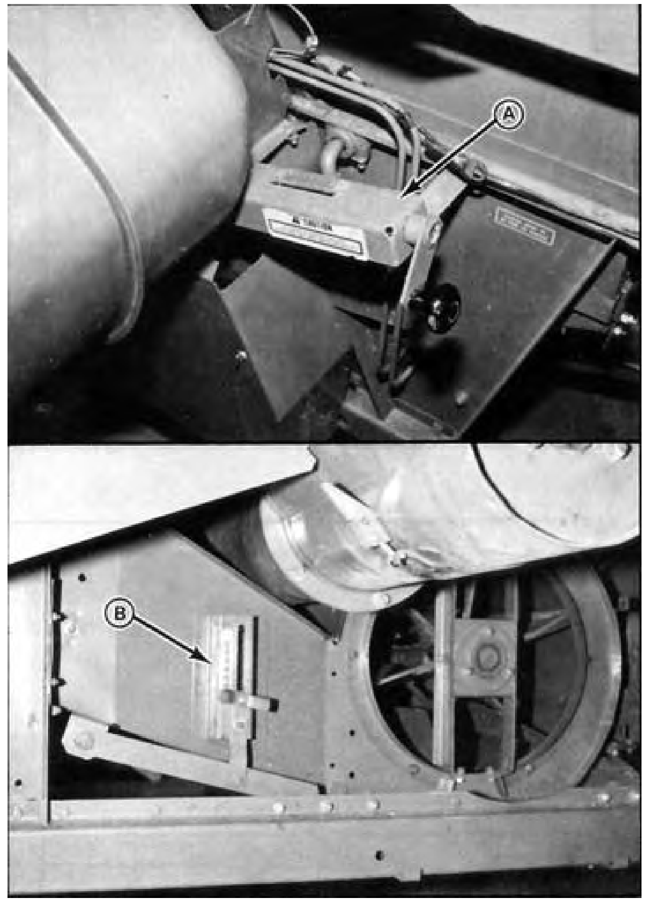

FIGURE 10. Shoe Adjustments (A) Fan Speed (B) Windboard.

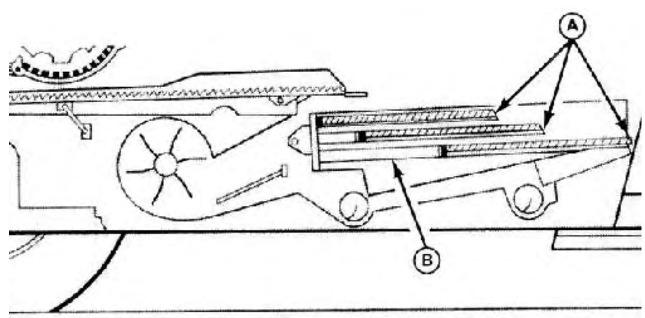

FIGURE 11. Triple Cascade Shoe (A) Adjustable Sieves (B) 8 mm Round Hole Screen.

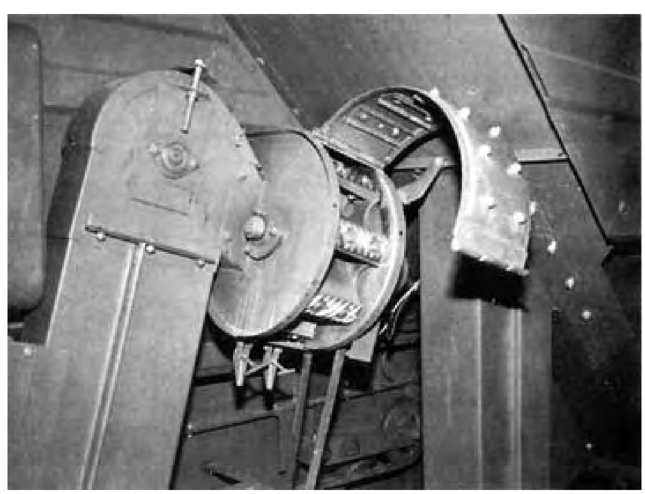

FIGURE 12. Rethresher.

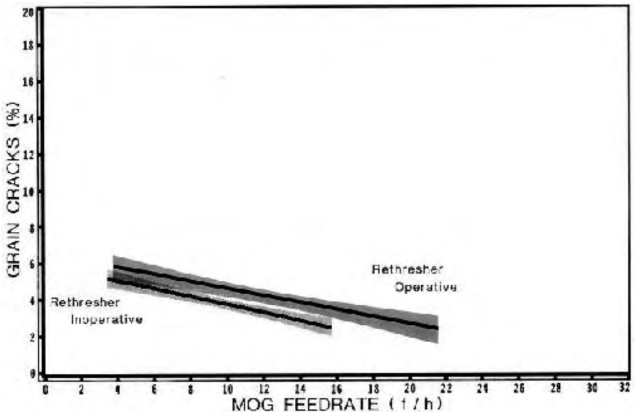

FIGURE 13. Grain Damage with Rethresher Operative and Inoperative.

It was very important to feed the windrow centred on the feeder housing, and to keep the cylinder width full thus ensuring uniform shoe loading. 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 Massey Ferguson 760 was evaluated only with a pickup attachment for windrowed crops. Straight combining attachments were not tested. The table could be removed from the feeder by one man in about 10 minutes. The complete header and feeder assembly could also be removed from the combine, but this was a more difficult job, taking two men about 45 minutes.

The table auger was easy to adjust both vertically and horizontally. Adjustment was seldom required.

Slip Clutches: Individual slip clutches protected the table auger, paddle feeder conveyor and tailings elevator.

RATE OF WORK

Average Work Rates: TABLE 3 presents the average workrates for the Massey Ferguson 760 in all crops harvested during the test. Average workrates are affected by crop conditions in a specific year and should not be used to compare 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 9.8 t/h in 2.8 t/ha Fielder wheat to 3.9 t/h in 1.7 t/ha Midas rapeseed.

Maximum Feedrate: The workrates given in TABLE 3 represent average workrates at acceptable loss levels. The engine had ample power to achieve higher feedrates in nearly all crops. In most crops, the maximum acceptable feedrate was limited by grain loss and the maximum feedrate was limited by table auger or feeder conveyor plugging. 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	2.6	5.9	2.6	6.9
Barley	Klages	2.5	5.2	2.6	6.3
Rapeseed	Midas	1.7	6.4	2.3	3.9
Rapeseed	Regent	1.6	6.4	2.3	5.3
Rye	Sangaste	2.3	5.9	2.1	4.8
Wheat	Canuck	2.6	6.0	2.4	6.2
Wheat	Fielder	2.8	5.6	3.6	9.8
Wheat	Glenlea	2.0	4.6	4.7	9.4
Wheat	Neepawa	3.0	5.3	2.5	7.5
Wheat	Sundance	2.8	6.6	2.5	6.9
Wheat	Wascana	2.3	5.2	2.0	4.5

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 quantity of grain being processed. Weight 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 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 straw walker 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 Massey Ferguson 760: TABLE 4 presents capacity results for the Massey Ferguson 760 in six different crops. MOG feedrates for a 3% total grain loss varied from 15 t/h in a field of 2.53 t/ha Canuck wheat to 6.9 t/h in 3.93 t/ha Bonanza barley.

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics for the Massey Ferguson 760 in the six crops described in TABLE 4 are presented in FIGURES 14 to 19.

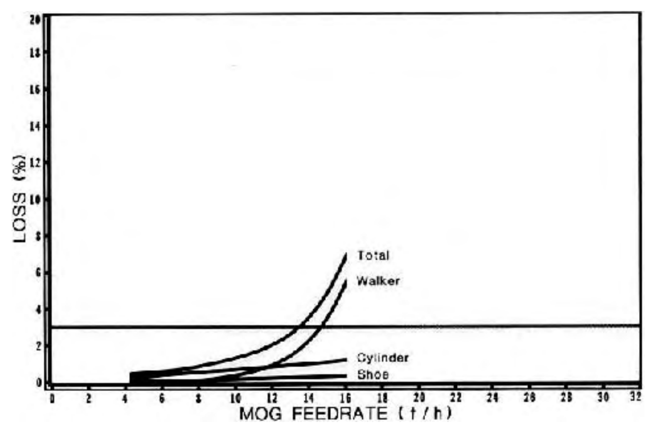

FIGURE 14. Grain Loss in Canuck Wheat.

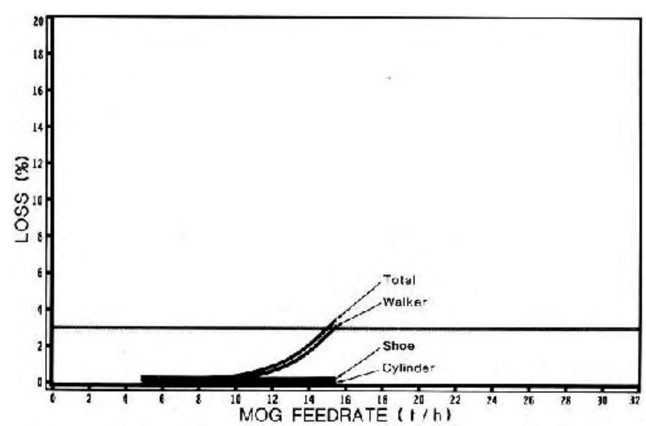

FIGURE 15. Grain Loss in Canuck Wheat.

Walker Loss: As is common with most combines, walker loss was the most significant factor limiting capacity in all grain crops. Cylinder loss and shoe loss usually were insignificant in comparison

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	6.1	2.41	6.7	12.6	0.99	13.5	13.6	9.3	Fig. 14
Wheat	Canuck	7.3	2.53	6.1	12.6	0.96	15.0	15.6	8.4	Fig. 15 & 20
Wheat	Lemhi[1]	11.0	2.27	7.9	11.8	0.74	14.1	19.1	7.6	Fig. 16 & 21
Wheat	Neepawa	6.1	4.28	9.5	14.6	1.09	7.8	7.2	2.8	Fig. 17
Wheat	Neepawa	6.1	3.04	10.6	16.5	1.14	9.3	8.2	4.4	Fig. 18 & 22
Barley	Bonanza	6.1	3.93	8.6	13.8	0.67	6.9	10.3	4.3	Fig. 19 & 23

[1]Side by Side Double Windrow

to walker loss. A reduction in free grain loss over the straw walkers would have enabled much higher combining rates especially in difficult-to-separate crops such as barley.

The Massey Ferguson 760 was equipped with a narrow-spaced concave and straw walker risers. All capacity measurements were conducted with the narrow spaced concave and the risers in place. Installation of the optional wide-spaced concave could possibly reduce grain losses over the straw walkers, especially in barley.

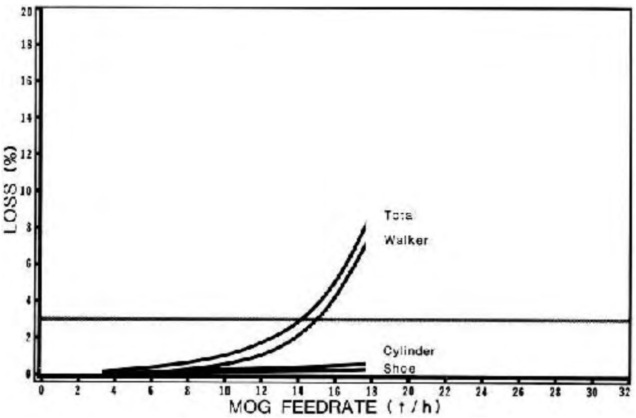

FIGURE 16. Grain Loss in Lemhi Wheat.

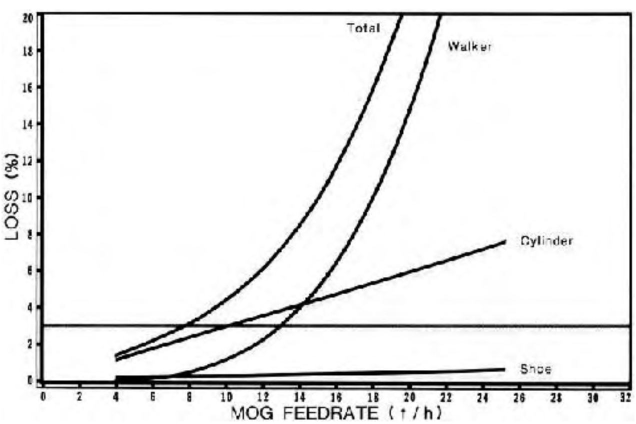

FIGURE 17. Grain Loss in Neepawa Wheat.

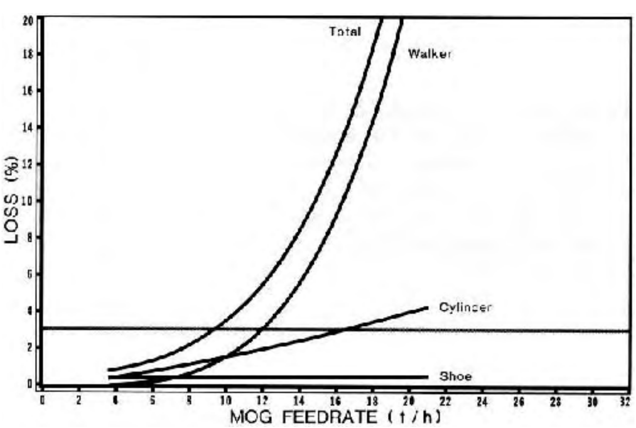

FIGURE 18. Grain Loss in Neepawa Wheat.

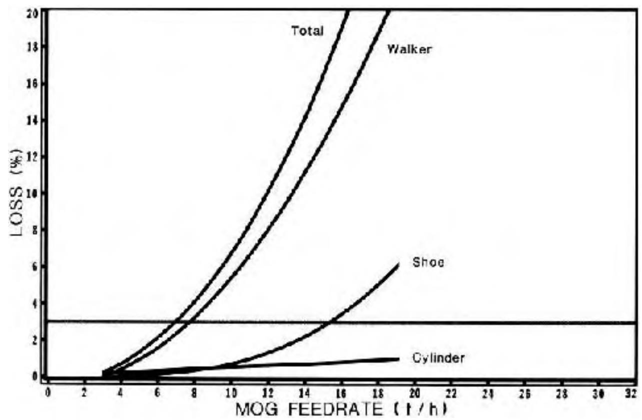

FIGURE 19. Grain Loss in Bonanza Barley.

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.

Cylinder Loss: Cylinder loss was low in most dry and well matured crops. In difficult to thresh crops, cylinder and concave adjustments were important and cylinder loss could make a significant contribution to total loss. FIGURE 17 shows high cylinder losses with improper cylinder and concave adjustment. In most difficult-to-thresh crops such as Neepawa wheat, accepting a cylinder loss of 1 to 2 percent was necessary to avoid higher losses through cracking.

Body Loss: Slight grain leakage occurred from the junction between the feeder housing and the combine body and from elevator and unloading auger doors, but was insignificant with proper adjustment.

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 along side 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 PAMI reference combine capacity results.

FIGURES 20 to 23 compare the total grain losses of the Massey Ferguson 760 and the PAMI reference combine in four of the crops described in TABLE 4. The shaded areas on the figures are the 95% confidence belts. If the shaded areas (confidence belts) overlap, 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 Massey Ferguson 760 was greater than the capacity of the reference combine and the Massey Ferguson 760 usually had lower grain losses than the reference combine when operating at the same feedrate.

OPERATOR SAFETY

The operator's manual contained appropriate safety suggestions.

The Massey Ferguson 760 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, but most of the shields were awkward to remove and difficult to attach, especially the shield covering the clean grain and return elevator drives. It is recommended that the manufacturer consider modifications to simplify shield removal and replacement. Although the upper body shrouding was aesthetically pleasing, it made repair and servicing very difficult. Many of the shields were designed with closed bottoms, which retained large amounts of chaff, making lubrication difficult and creating potential fire hazards.

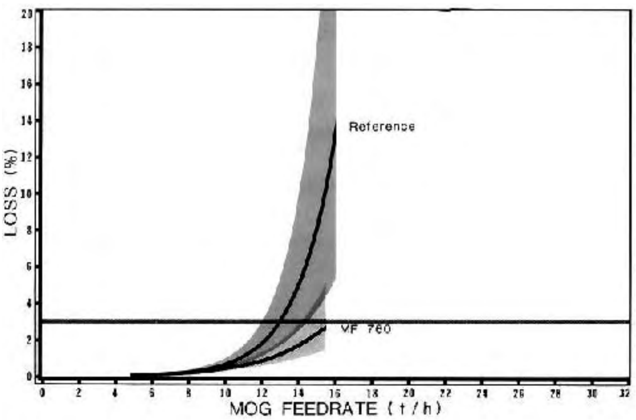

FIGURE 20. Total Grain Losses in Canuck Wheat.

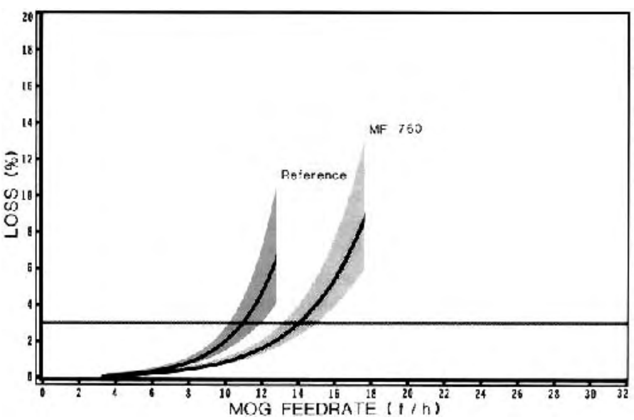

FIGURE 21. Total Grain Losses in Lemhi Wheat.

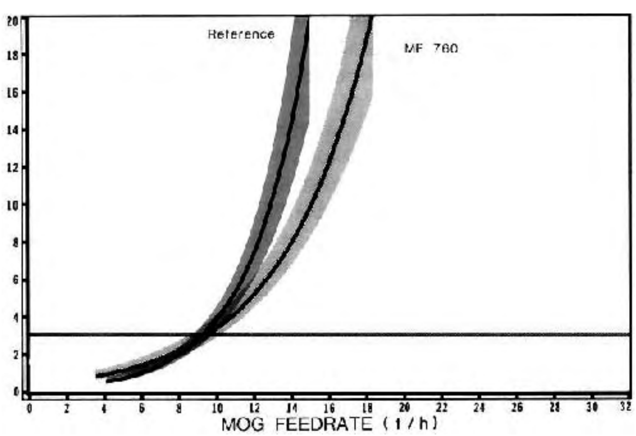

FIGURE 22. Total Grain Losses in Neepawa Wheat.

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

No rocking wrench or hub was provided for unplugging the feeder auger. This necessitated entry into the header, which was difficult and hazardous. An auger rocking wrench and hub would improve operator safety.

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

No attempt should be made to sample the tailings from the access holes provided, as these are hazardous pinch points and serious hand injury could result.

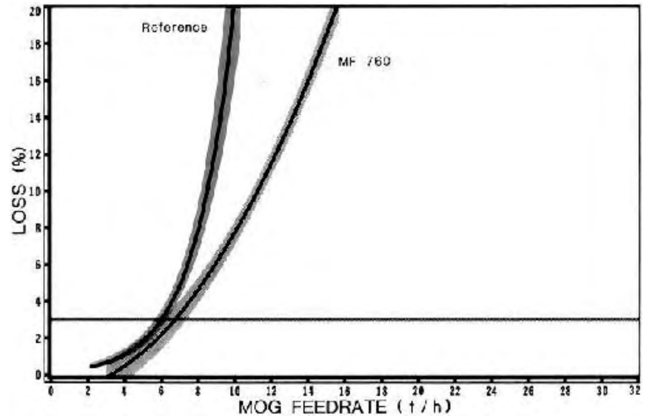

FIGURE 23. Total Grain Losses in Bonanza Barley.

When using the slug wrench to unplug the cylinder, or when unplugging the table auger or feeder housing, the engine should be shut off and the separator clutch disengaged. Gaining access to the front of the engine was inconvenient, requiring the operator to climb onto the feeder housing. In addition, extreme caution must be used when mounting the platform behind the cab. The grain tank is extremely hazardous and should not be entered unless the engine is shut off. Extreme caution is required when crossing the grain tank to gain access to the straw walkers.

If recommended safety procedures were followed, all adjustments could be safely made.

Pinch points existed in the operator's cab between the concave adjusting lever and the cab heater housing and between the grain unloading auger lever and the emergency brake.

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

OPERATOR'S MANUAL

The operator's manual was well illustrated and contained detailed information on adjustments and combine settings, but the lubrication section was difficult to follow as up to four references were needed to locate a fitting. A schematic, including a description of the fittings on the same page, would be more suitable.

Initial suggested concave clearances were too tight and cylinder speeds too high for rapeseed and these initial settings should be revised.

It is recommended that the operator's manual be revised to provide a clearer lubrication procedure and new initial rapeseed settings.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the Massey Ferguson 760 during 109 hours of operation while combining about 270 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.

TABLE 5. Mechanical History

Item	Operating Hours	Field Area ha
Hydraulic System		
-An orifice plugged in the header lift solenoid valve causing sluggish operation and was cleaned at	1	2
-The main hydrostatic pump seal began leaking at	102	260
Drives		
-The cylinder variable speed drive belt was burned when the cylinder plugged. The belt was replaced at	73	186
-The pickup variable speed control jammed at maximum speed and was freed at	68	175
Engine		
-To improve sluggish engine performance the fuel filters were changed at	46	117
-The batteries went dead requiring recharging at	80	203
-An engine compartment fire occurred due to chaff accumulation at	97	242
Miscellaneous		
- A rethresher access door T-bolt broke and was replaced at	13	28
-The grain unloading light burned out and was replaced at	14	30
-A loose set screw in the straw chopper alarm drive caused premature warning. It was secured at	16	33

APPENDIX I
SPECIFICATIONS

MAKE:	Massey Ferguson Self-Propelled Combine
MODEL:	760
SERIAL NUMBER:	Header 1859-43514, Combine 1746-8983, Engine U511186D
MANUFACTURER:	Massey Ferguson Industries Ltd. 915 King Street West Toronto, Ontario M6K 1E3
WINDROW PICKUP:	
--make and model	Melroe 351-12
--type	aluminum apron with rubber draper
--pickup width	3200 mm
--number of belts	7
--teeth per belt	40
--type of teeth	spring steel
--number of rollers	
-apron	2
-draper	2
--eight control	castor wheels and support chains
--speed control	variable pitch sheaves electrically controlled
--apron speed range	0.6 to 1.4 m/s
HEADER:	
--type	centre feed
--width	3960 mm
--auger diameter	508 mm
--feeder	5 fabric belted paddles
--paddle speed	260 rpm
--range of picking height	-305 to 1260 mm
--number of lift cylinders	2
--raising time	6 s
--lowering time	adjustable
--options	header cutting equipment, header height control, auger flight extensions, table bottom plates, paddle shields, extra lift cylinders, electromagnetic header clutch, variable speed pickup drive
FEEDER BEATER:	
--type	four blade integral
--diameter	145 mm
--speed	740 rpm
CYLINDER:	
--type	rasp bar
--number of bars	8
--diameter	558 mm
--width	1505 mm
--drive	crank controlled variable pitch belt
--speed range	
-low gear	340 to 760 rpm
-high gear	550 to 1210 rpm
--stripper	bar steel
--options	double range cylinder drive, high inertia cylinder
CYLINDER BEATER:	
--type	drum with 6 triangular bats
--diameter	380 mm
--speed	705 rpm
CONCAVE:	
--type	bar and wire grate
--number of bars	11
--configuration	8 intervals with alternating 6.4 mm and 4.8 mm wires and 7 mm spaces
--area	0.794 m²
--transition grate area	0.328 m²
--wrap	107°
--grain delivery to shoe	grain pan
--options	stone trap cover, filler bars, wide spaced concave, grain pan screens
STRAW WALKERS:	
--type	rotary, formed metal
--number	6
--length	3035 mm
--walker housing width	1710 mm
--separating area	5.19 m²
--crank throw	102 mm
--speed	210 rpm
--grain delivery to shoe	grain pan
--options	risers
SHOE:	
--type	single action triple sieve
--speed	315 rpm
--top sieve	adjustable lip, 1.316 m² with 40 mm throw
--middle sieve	adjustable lip, 1.316 m² with 40 mm throw
--bottom sieve	
-front	8 mm fixed round hole screen, 0.966 m² with 40 mm throw
-rear	adjustable lip, 1.316 m² with 40 mm throw
--options	miscellaneous screens
RETHRESHER:	
--type	rasp bar cylinder with closed concave
--number of bars	8
--diameter	337 mm
--width	114 mm
--speed	815 rpm
CLEANING FAN:	
--type	6 blade undershot dual fans
--diameter	480 mm
--width of each fan	500 mm
--drive	crank controlled variable pitch belt
--speed range	610 to 1010 rpm
--options	small seed kit, air intake screens
ELEVATORS:	
--type	roller chain with rubber flights, top delivery
--clean grain (bottom drive)	152 x 254 mm
--tailings (bottom drive)	102 x 254 mm
GRAIN TANK:	
--capacity	6.11 m³
--unloading time	126 s
--options	unloading tube extension
STRAW CHOPPER:	
--type	rotor with 41 freely swinging hammers
--speed	2960 rpm
--options	straw spreader
ENGINE:	
--make and model	Perkins AV8.540
--type	4 stroke naturally aspirated diesel
--number of cylinders	8
--displacement	8.85 L
--governed speed (full throttle)	2400 rpm
--manufacturer's rating at 2600 rpm	104 kW
--fuel tank capacity	340 L
--options	hour meter, ether starting assist, air restriction indicator, pre-cleaner and safety element, exhaust spark arrestor, cyclone air intake screen
CLUTCHES:	
--header	electromagnetic
--separator	V-belt
--unloading auger	V-belt
--traction drive	hydraulic valve
NUMBER OF CHAIN DRIVES:	12
NUMBER OF BELT DRIVES:	19
NUMBER OF GEAR BOXES:	2
NUMBER OF PRELUBRICATED BEARINGS:	83
LUBRICATION POINTS:	
--10 h lubrication	27
--50 h lubrication	13
--100 h lubrication	1
--500 h lubrication	4
TIRES:	
--front	23.1 x 30 R1, 10-ply
--rear	14 L x 16.1, 6-ply
TRACTION DRIVE:	
--type	hydrostatic
--speed ranges (23.1 x 30 R1 tires)	
-1st gear	0 to 3.4 km/h
-2nd gear	0 to 7.5 km/h
-3rd gear	0 to 11.0 km/h
-4th gear	0 to 24.3 km/h

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations, for the capacity results shown in FIGURES 14 to 19 are presented in TABLE 6. In the regressions, C = cylinder loss in percent of yield. S = shoe loss in percent of yield. W = straw walker 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 19 while crop conditions are presented in TABLE 4.

TABLE 6. Regression Equations

Crop - Variety	Fig. No.	Regression Equations	Simple Correlation Coefficient	Variance Ratio	Sample Size
Wheat - Canuck	14	$C = -0.10 + 0.08F$ $S = 0.003 + 0.02F$ $\ln W = -5.38 + 0.44F$	0.98 0.89 0.99	157.6[2] 28.99[2] 340.9[2]	10
Wheat - Canuck	15	$C = -0.02 + 0.01F$ $S = 0.05 + 0.01F$ $W = 0.16 - 0.0015F^3$ $+ 0.00015F^4$	0.62 0.79 0.99	5.04 13.29[2] 808.5[2]	10
Wheat - Lemhi	16	$C = -0.09 + 0.04F$ $S = -0.01 + 0.02F$ $\ln W = -3.85 + 0.33F$	0.90 0.90 0.78	30.68[2] 28.96[2] 9.77[1]	9
Wheat - Neepawa	17	$C = 0.01 + 0.30F$ $S = 0.01 + 0.02F$ $\ln W = -8.35 + 3.69 \ln F$	0.94 0.92 0.99	60.77[2] 42.27[2] 593.2[2]	10
Wheat - Neepawa	18	$\ln C = -2.71 + 1.37 \ln F$ $S = 0.37 + 0.005F$ $\ln W = -8.36 + 3.82 \ln F$	0.98 0.37 0.99	193.9[2] 1.08 330.2[2]	9
Barley - Bonanza	19	$C = 0.11 + 0.05F$ $\ln S = -7.86 + 3.82 \ln F$ $W = -0.51 + 0.05F^7$	0.63 0.95 0.99	5.35[2] 78.20[2] 583.9[2]	10

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

APPENDIX III
PAMI REFERENCE COMBINE AND CAPACITY RESULTS

TABLE 7 and FIGURES 24 and 25 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 24 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 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 (even 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.

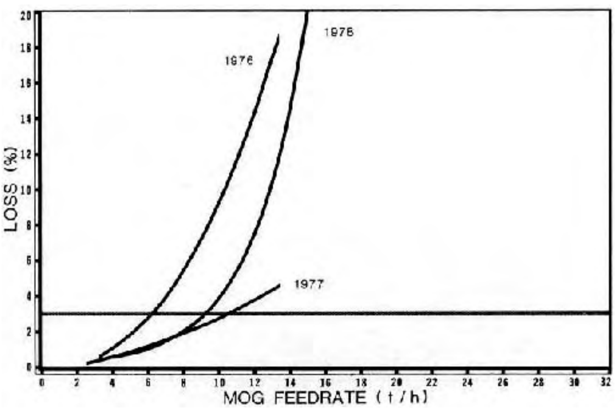

FIGURE 24. Total Grain Losses for the PAMI Reference Combine in Neepawa Wheat.

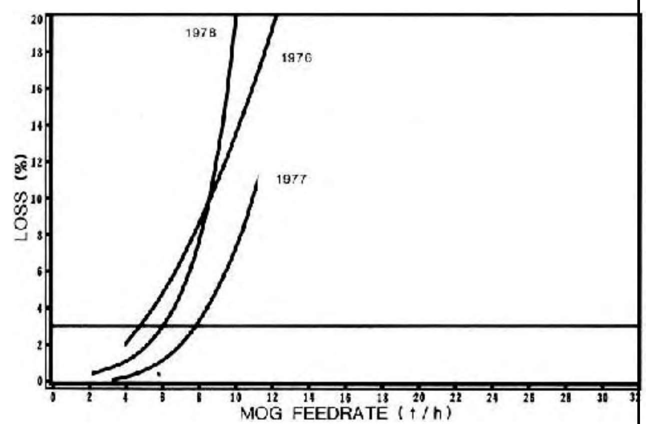

FIGURE 25. Total Grain Losses for the PAMI Reference Combine in Bonanza Barley.

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	
	Crop	Variety	Width of Cut m	Crop Yield t/ha	Straw %	Grain %	MOG/G	t/h	t/h	km/h	Loss Curve
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. 24
	Barley	Bonanza	6.1	4.06	7.7	13.5	0.68	6.1	9.0	3.6	Fig. 25
1977	Wheat	Neepawa	6.1	3.97	13.4	14.6	0.79	11.1	14.1	5.8	Fig. 24
	Barley	Bonanza	7.3	4.74	25.7	14.6	0.84	7.9	9.4	2.7	Fig 26
1976	Wheat	Neepawa	5.5	2.78	dry to tough	14.7	1.29	7.1	5.5	3.6	Fig. 24
	Barley	Bonanza	7.3	3.18	dry to tough	14.6	0.96	4.8	5.0	2.2	Fig 25

1.Side by Side Double Windrow.

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:
(a) excellent (d) fair
(b) very good (e) poor
(c) good (f) un satisfactory

APPENDIX V
METRIC UNITS

In keeping with the Canadian metric conversion program, this report has been prepared in S1 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)

ALBERTA FARM MACHINERY RESEARCH CENTRE

3000 College Drive South
Lethbridge, Alberta, Canada T1K 1L6
Telephone: (403) 329-1212
FAX: (403) 329-5562
http://www.agric.gov.ab.ca/navigation/engineering/afmrc/index.html

Prairie Agricultural Machinery Institute
Head Office: P.O. Box 1900, Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-2555

Test Stations:
P.O. Box 1060
Portage la Prairie, Manitoba, Canada R1N 3C5
Telephone: (204) 239-5445
Fax: (204) 239-7124

P.O. Box 1150
Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-5033
Fax: (306) 682-5080