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Evaluation Report 98

John Deere Model 510 Round Baler

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

JOHN DEERE MODEL 510 ROUND BALER

MANUFACTURER:
John Deere Ottumwa Works
Ottumwa, Iowa 52501
U.S.A.

DISTRIBUTOR:
John Deere Limited
455 Park Street
Regina, Saskatchewan, Canada
S4P 3L8

RETAIL PRICE:
$8,266.75 (May, 1978, f.o.b. Humboldt).

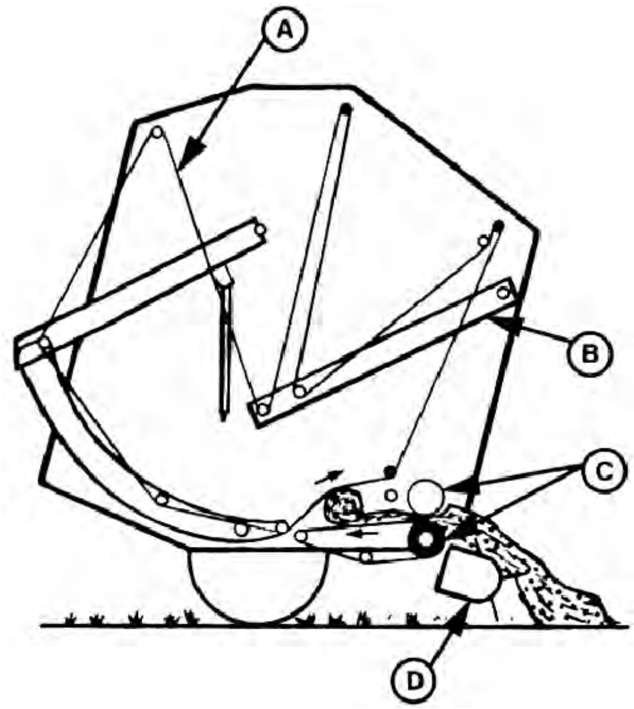

FIGURE 1. John Deere 510 Round Baler: (A) Bale Forming Belts, (B) Tensioning Arm, (C) Compression Rollers, (D) Pickup.

SUMMARY AND CONCLUSIONS

Overall functional performance of the John Deere 510 round baler was very good but was reduced by feeding problems in long coarse-stemmed crops. Ease of operation and adjustment both were good. Operation of the twine wrapping mechanism was good.

Average eld speeds varied from 7 to 17 km/h (4.3 to 10.6 mph) while average throughputs varied from 1.8 to 7.5 t/h (2.0 to 8.3 ton/h). Maximum instantaneous feedrates of up to 17 t/h (18.7 ton/h) were measured in heavy, uniform alfalfa windrows. Ground speed was usually limited by pickup loss and not by baler capacity. Feeding was aggressive in nearly all crops. In long coarse-stemmed crops, such as sweet clover, capacity was reduced by unsatisfactory feeding through the compression rollers.

Bales were well formed and neat in appearance. The John Deere 510 produced bales with an average length of 1.6 m (63 in) and an average diameter of 1.8 m (71 in). Hay bales weighed from 550 to 1050 kg (1213 to 2315 lb) with an average density of 215 kg/m³ (13.4 Ib/ft³).

Resistance of bales to moisture penetration was good.

Peak power take-off requirements were about 20 kW (27 hp) in hay and 18 kW (24 hp) in straw on at terrain under normal conditions. More power was required in hills or soft ground.

Leaf loss was comparable to that of other large round balers. In heavy windrows at near optimum moisture content, bale chamber loss was 2% while pickup loss was 5%. In light dry alfalfa, average bale chamber loss was 17% and pickup loss was 12%. Heavy windrows, proper conditioning and baling at the maximum permissible moisture content all were important in reducing bale chamber loss.

The John Deere 510 was safe to operate if the manufacturer's safety recommendations were closely followed.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modi cations to eliminate malfunction of the gate latch due to hay accumulation on the latch mechanism.
2. Modi cations to the twine wrapping system to provide a uniform speed of travel of the twine tube across the bale face.
3. Modi cations to improve feeding in long coarse-stemmed crops.
4. Modi cations to reduce bale forming belt failure while discharging heavy bales.

Chief Engineer -- E. O. Nyborg
Senior Engineer -- L. G. Smith
Project Technologist -- D. H. Kelly

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. An indicator is provided for visual monitoring of the latch function. Provided the operator always makes certain the indicator is in the locked position while making a bale, accumulation of hay in this area will not affect machine function. Because of this, no modi cation program is presently being contemplated.
2. The speed of travel of the twine arm is determined by adjusting the hydraulic ow control valve. When close twine spacing is desired, best results can be achieved by reducing the control valve setting to decrease the arm speed. The PTO speed can also be a determining factor in the number of wraps and the spacing between wraps. Increasing the pro speed and slowing the twine arm speed increases the number of wraps. An alternate method to control the twine arm is to index the arm with the tractor hydraulic control lever. With the ow control valve in the fast or open setting, the operator can bump the hydraulic lever to apply as many wraps as desired.
3. Feeding of coarse stem materials can be improved by adding more pickup compression bars. It is also bene cial to raise the pickup as high as is possible to still pick up all the crop. Conditioning the crop improves not only feeding, but also bale density and appearance and improves acceptance as an animal feed.
4. There is some question whether the primary cause of failures on bale forming belts is discharging of heavy bales. The highest loads during normal operation may occur during the nal stage of bale formation and bale discharge; however, failures generally can be traced to earlier partial failures or weakening of belts resulting from the machine being plugged during bale starting. In formation has been provided to dealers and customers to better inform and educate them in correct bale starting procedures that will reduce belt failures associated with bale starting. No other modi cation is planned at this time.

MANUFACTURER'S ADDITIONAL COMMENTS

1. The problem of platform belts turning inside out can be caused by running the power take-off while discharging a bate. The operator's manual states that the power take-off should not be engaged while discharging a bale.

GENERAL DESCRIPTION

The John Deere Model 510 is a pull-type, power take-off driven baler with a cylindrical baling chamber and a oating drum pickup. The twine wrapping mechanism is hydraulically actuated.

Hay is fed to the baling chamber between two compression rollers. The upper roller is rubber covered while the surface of the lower roller is covered with the platform belts. The baling chamber consists of seven 203 mm (8 in) wide platform belts on the bottom and nine 102 mm (4 in) wide forming belts on top. Platform belt position is xed while the forming belts are spring-loaded to position themselves around the bale during formation.

Detailed speci cations are given in APPENDIX I.

SCOPE OF TEST

The John Deere 510 was operated in a variety of Saskatchewan crops (TABLES 1 and 2) for 100 hours while producing 558 bales. It was evaluated for rate of work, quality of work, power consumption, ease of operation, ease of adjustment, operator safety and suitability of the operator's manual.

TABLE 1. Operating Conditions

Crop	Hours	Number of Bales	Field Area	
			ha	ac
Alfalfa	19	94	36	89.0
Alfalfa, Bromegrass & Crested Wheatgrass	34	121	60	148.0
Alfalfa & Spring Rye mixture	17	51	36	89.0
Green Feed	7	31	9	22.0
Slough Hay	1	6	1	2.5
Wheat Straw	12	129	25	62.0
Oat Straw	2	47	10	25.0
Barley Straw	3	36	5	12.5
Oat & Wheat Straw	5	43	9	22.0
Total	100	558	191	472

TABLE 2. Operation in Stony Fields

Field Conditions	Hours	Field Area	
		ha	ac
Stone Free	66	126	311
Occasional Stones	17	32	79
Moderately Stony	16	31	77
Very Stony	1	2	5
Total	100	191	472

RESULTS AND DISCUSSION

RATE OF WORK

Average throughputs for the John Deere 510 (TABLE 3) varied from 1.8 t/h (2.0 ton/h) in an alfalfa and spring rye mixture to 7.5 t/h (8.3 ton/h) in oat straw. The average throughputs reported in TABLE 3 are average workrates for daily field operation. They are representative of the actual workrates that may be expected in typical field operation. These values are based on the total operating time and the total baler throughput for each day of baling.

In heavy, uniform alfalfa windrows, instantaneous feedrates up to 17 t/h (18.7 ton/h) were measured. These were peak values, representing maximum baler capacity, which cannot be achieved continuously.

In most crops, the feedrate was limited by pickup performance and not by bale chamber capacity. Pickup loss usually limited ground speed from 7.0 to 17.0 km/h (4.3 to 10.6 mph). Heavy windrows were desirable to fully utilize baler capacity.

Feeding was aggressive in all crops except in long coarse-stemmed hay where capacity was reduced by feeding problems and plugging at the compression rolls, limiting the throughput to about 2.6 t/h (2.9 ton/h), or less.

TABLE 3. Average Throughputs

Crop	Yield		Average Speed		Average Throughput	
	L/ha	ton/ac	km/h	mph	t/h	ton/h
Alfalfa	0.6-4.0	0.3-1.8	7.0	4.3	4.4	4.9
Alfalfa, Bromegrass & Crested Wheatgrass	0.7-4.7	0.3-2.1	8.2	5.1	4.7	5.2
Alfalfa & Spring Rye mixture	0.7-1.0	0.3-0.4	9.1	5.7	1.8	2.0
Green Feed	3.0	1.3	1.7	1.1	3.9	4.3
Slough Hay	1.0-3.0	0.4-1.3	7.0	4.3	2.0	2.2
Wheat Straw	1.5-2.0	0.7-0.9	13.0	8.0	3.6	4.0
Oat Straw	1.0-2.0	0.4-0.9	17.0	10.6	7.5	8.3
Barley Straw	1.0-2.0	0.4-0.9	11.0	6.8	2.5	2.8
Oat & Wheat Straw	1.0-2.0	0.4-0.9	9.0	5.6	2.7	3.0

QUALITY Of WORK

Bale Quality: The John Deere 510 produced firm, durable bales (FIGURE 2) with flat ends, uniform density and uniform diameter. Bales averaged 1.6 m (63 in) in length and 1.8 m (71 in) in diameter. Average hay bales weighed from 550 to 1050 kg (1213 to 2315 lb) with an average density of 215 kg/m³ (13.4 lb/ft³).

FIGURE 2. Typical Hay or Straw Bale.

Bale Weathering: A common practice in the prairie provinces is to store round bales outside. FIGURE 3 shows the effect of weathering on a typical John Deere 510 hay bale (bromegrass and alfalfa mixture) after 100 days of weathering. The weathering period was the time between baling and freeze-up. Bales were situated in a well-drained area with prevailing winds striking one side of the bales. During weathering, bales were exposed to about 75 mm (3 in) of rain and average prairie wind conditions.

The condition of weathered bales was good. The relatively high bale density and the well formed surface had kept moisture penetration to a maximum of 90 mm (3.5 in) on the windward bale side. Bales had retained 94% of their original height. As a result, bales were easy to pick with round bale handlers.

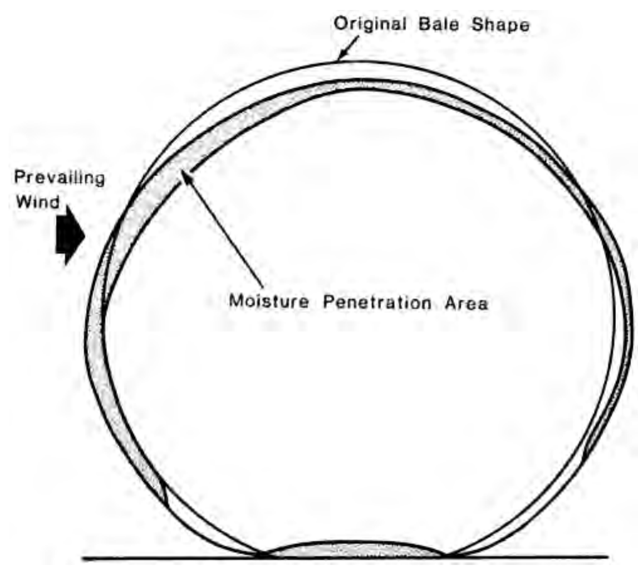

FIGURE 3. A Typical Hay Bale After 100 Days of Weathering.

Pickup and Bale Chamber Loss: Measured hay loss from the John Deere 510 (TABLE 4) varied from 7% in heavy windrows to 29% in light dry windrows. Bale chamber loss usually was nearly twice as high as pickup loss.

TABLE 4. Pickup,and Bale Chamber Losses

Crop	Yield		Swath Width		Moisture Content	Loss % of yield		
	t/ha	ton/ac	m	ft	% dry basis	Bale Chamber	Pickup	Total
Alfalfa	3.4	1.5	3.7	12	20.6	10	4	14
Alfalfa	2.8	1.3	3.7	12	17.6	10	5	15
Alfalfa & Bromegrass	4.0	1.8	4.6	15	9.7	2	5	7
Alfalfa & Bromegrass	1.4	0.6	4.6	15	10.2	17	12	29

Lowest losses occurred in windrows which were heavy enough to fully utilize baler capacity and which were baled at high moisture contents. Proper conditioning of hay was important, especially in alfalfa, to reduce the moisture content of the stems and to permit baling with a fairly high leaf moisture content. While the moisture content of the unconditioned alfalfa windrow may be at a level to just permit safe storage, the leaves may be quite dry and brittle and susceptible to shattering. The fourth crop reported in TABLE 4 illustrates the high losses, which may occur when a windrow is too light to fully utilize baler capacity and is baled at too low a moisture content. Proper conditioning of the windrow and cutting a wider swath would probably have reduced losses to an acceptable level in this crop.

To minimize bale chamber losses with a round baler, the feedrate should be as high as possible to minimize time in the baling chamber. This is illustrated by the third and fourth crops reported in TABLE 4. Both crops were baled at about 10% moisture. In the third crop, it took only two minutes to form a bale and losses were only 7%. In the fourth crop, it took 13 minutes to form a bale and losses were 29%. It is often more economical to allow some pickup loss, by driving too fast, as the total loss level will be reduced due to a decreased bale chamber loss. Bale chamber losses in light crops can also be reduced by running the tractor at a lower power take-off speed. This results in fewer turns to form a bale. Power take-off speed must, however, be fast enough for satisfactory pickup performance.

POWER CONSUMPTION

Power Requirements: FIGURE 4 shows the power take-off and drawbar input for the John Deere 510 in alfalfa. The power input is plotted against bale weight to show the power requirements as a bale is being formed. Power take-off input varied from 3 kW (4 hp) at no load to a maximum of 20 kW (27 hp) in alfalfa and 18 kW (24 hp) in barley straw. Drawbar requirements at 7 km/h (5.5 mph) were 3 kW (4 hp).

Although maximum power requirements did not exceed 23 kW (31 hp), additional power was needed to suit field conditions. In soft, hilly fields a 75 kW (100 hp) tractor was needed to fully utilize baler capacity.

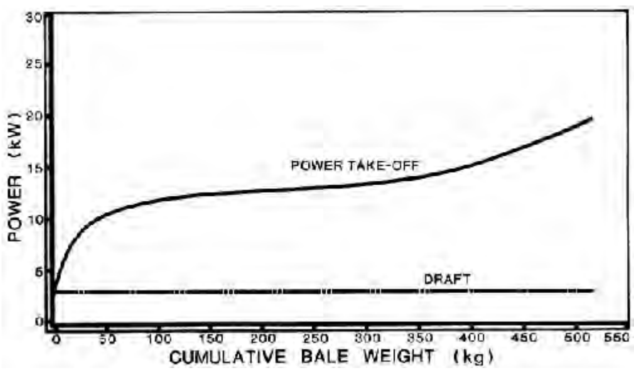

FIGURE 4. Power Consumption During Bale Formation.

Specific Capacity: Specific capacity is a measure of how efficiently a machine performs a task. A high specific capacity indicates efficient energy use while low specific capacity indicates inefficient operation. The specific capacity of the John Deere 510 was about 0.65 t/kW•h (0.54 ton/hp•h) in alfalfa and 0.55 t/kW•h (0.45 ton/hp•h) in barley straw. This compares to an average specific capacity of 0.98 to 1.45 t/kW•h (0.8 to 1.2 ton/hp•h) for small square balers in alfalfa. These values represent average operating speeds in average field conditions and not peak outputs.

EASE OF OPERATION

Forming a Bale: It was easy to form a neat, durable bale with the John Deere 510. Proper bale formation depended greatly on correct bale core formation. When starting a bale, it was necessary to weave the baler, back and forth across the windrow, so hay was fed evenly across the width of the baling chamber to form a uniform core. It was easiest to start a bale by feeding the windrow at one extreme end of the pickup and moving across the windrow to the other side as rapidly as possible. A weaving action was also needed during bale formation to maintain a uniform diameter. FIGURE 5 shows the position of the bale forming belts during bale formation.

Wrapping the Twine: A mechanical indicator at the front of the baler tells the operator when a bale is full size and ready for twine wrapping. As a safety device, an adjustable pickup release disengages the pickup drive to prevent overfilling the baler.

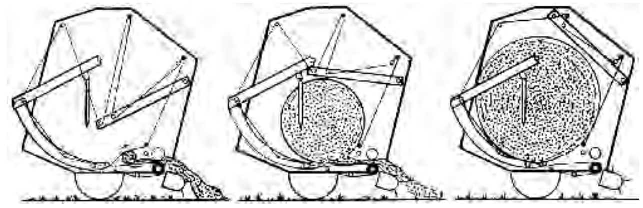

FIGURE 5. Stages of Bale Formation: (Left) Bale Core, (Centre) Half-Completed Bale, (Right) Completed Bale.

To start wrapping, the twine tube is hydraulically moved to the left of the bale chamber. Once the twine has been caught by the hay entering the feed rolls and has made at least a full wrap around the left end of the bale, the hydraulic control is actuated to move the tube across the front of the bale chamber and the tractor forward travel is stopped but the power take-off is allowed to run. The return speed of the twine tube and subsequently, the number of twine wraps is determined by an adjustable flow control valve. When the twine tube reaches the right side, the hydraulic lever is momentarily released so there is at least one complete twine wrap around the bale end. The lever is then actuated to move the twine tube further to the right against the twine cutting anvil.

Some problems occurred with twine catching on the twine cutter anvil and not wrapping properly. These problems were reduced by feeding the baler on the left side when beginning to wrap. Problems also occurred with the hydraulic twine tube moving faster on the left side of the bale than on the right side. As a result, too few wraps were placed on the left bale end and too many wraps on the right bale end. Modification to the twine system to eliminate this problem is recommended.

Twine consumption for the John Deere 510 was about 71 m/t (212 ft/ton). This compares to a twine consumption of about 225 m/t (670 ft/ton) for small square balers.

Discharging a Bale: Once the twine is cut, the power take-off is shut off and the tractor and baler are backed up about 6 m (20 ft). The gate is hydraulically opened to discharge the bale. The tractor and baler are then moved ahead about 4.5 m (15 ft) and the gate closed. A slight pressure is required on the gate hydraulic cylinders to ensure that the gate latch is locked. About one minute was needed to wrap and discharge a bale.

During baling, fine hay accumulated between the bale forming belts (FIGURE 6). When discharging the bale, this hay usually fell on the rear gate latch and sometimes prevented the latch from locking when the gate was closed. If the latch was not locked, the rear gate opened during baling, preventing proper bale formation. Modification to the rear gate latch to eliminate locking problems is recommended.

Splices on individual bale forming belts broke three times during bale discharge. Belt failure appeared to be due to shock loading of the belts during discharge of heavy bales. The belt tensioning roller tightens the bale forming belts abruptly during bale discharge. Modifications to eliminate forming belt failure during bale discharge are recommended.

FIGURE 6. Hay Accumulation Between Belts.

Transporting: The John Deere 510 was easy to manoeuvre and transport. Ground clearance was adequate and there was ample hitch clearance for turning sharp corners. The baler could easily be towed behind a tractor or a suitably sized truck.

Hitching: The John Deere 510 baler was supplied with an "equal angle hitch" attachment, which bolts as an extension to the tractor drawbar. This design reduced driveline noise and allowed 90° turns during baling. Modifications to some tractor drawbars were necessary to allow proper mounting of the extension.

The John Deere 510 requires a tractor with dual hydraulics. Alternatively, an optional flow dividing valve is available for tractors with single hydraulics.

Feeding: Feeding was positive and aggressive in nearly all crops with only infrequent plugging. One exception was in long, coarse-stemmed hay, such as sweet clover. In such crops, stalks often fed up the front of the forming belts (FIGURE 7) rather than through the compression rollers, causing plugging. Modifications are recommended to reduce feeding problems in long, coarse-stemmed hay.

FIGURE 7. Plugging in Long Coarse-Stemmed Hay.

Twine Threading: Twine threading was difficult. A length of stiff wire was needed to thread the twine through the twine tube. The operator's manual gave a clear description of twine threading procedures.

The twine cutter performed well but periodic adjustments, as outlined in the operator's manual, were needed to ensure proper twine cutting.

EASE OF ADJUSTMENT

Compression Rollers: The upper compression roller was held against the platform belt drive roller with adjustable springs. The operator's manual recommended that maximum contact pressure be maintained. All evaluation was conducted with maximum spring pressure; no adjustment was required during the test.

Forming Belts: Two adjustable springs maintain tension in the forming belts. No adjustment was required during the test once the springs had been set to the manufacturer's recommended length.
The forming belts were chain driven through the upper rollers. The drive chain needed periodic adjustment.

Platform Belts: Adjustable springs maintained tension in the platform belts. Frequent adjustment of the tensioning springs was necessary to accommodate changes in belt length. Since the platform belts were endless, major baler disassembly was required should individual belts need replacement.

Pickup: Pickup flotation was controlled by an adjustable spring while ground clearance was adjusted by a hand crank. The hand crank was also used to raise the pickup into the transport position. The pickup drive belt had a spring-loaded tightener and did not need adjustment during the test.

The pickup compression bars were not adjustable. The operator's manual recommended that the compression bars be installed only in light, short hay or windy days or in corn stalks. The compression bars were used throughout the test and performed well in all crops, except long coarse-stemmed material. Under these situations the compression bars flexed excessively allowing hay to feed above the compression rollers.

The pickup tine pattern was circular and no adjustment of tine pattern was possible.

Servicing: The John Deere 510 had five chain drives, three grease fittings and one gearbox. The operator's manual recommended chain oiling every 10 hours, lubrication of all grease fittings every 30 hours and checking gearbox oil level and repacking the wheel bearings every season. About 10 minutes were needed to service the John Deere 510.

OPERATOR SAFETY

The John Deere 510 was safe to operate and service as long as common sense was used and the manufacturer's safety recommendations were followed. Rotating parts were well shielded. The pickup and compression rollers were well shielded to discourage operators from attempting to clear blockages with the baler in operation.

On one occasion a small tree branch wedged between the compression rollers. No damage resulted as the baler was stopped before the compression rollers became hot enough to cause a fire hazard. As indicated in the operator's manual a fire extinguisher should be mounted on the baler or tractor especially when baling newly cleared land or stony fields.

The John Deere 510 had a rear gate cylinder lock to permit safe servicing while the rear gate was open.

The John Deere 510 was equipped with an automatic pickup release that disengaged the pickup belt drive when the bale chamber was full. This acted as a safety device to protect the baler from damage due to overfilling the bale chamber. It was also equipped with an adjustable slip clutch on the main power take-off drive.

GENERAL SAFETY COMMENTS

The operator is cautioned that a round baler is potentially very dangerous. The operator must disengage the power take-off and stop the tractor engine to clear blockages or to make adjustments.
Many serious and fatal accidents have occurred with round balers. Most of these are caused by operators dismounting from the tractor while leaving the baler running. The manufacturer can only go to certain limits in providing shielding and safety devices and must rely on the operator's common sense in following established safety procedures.

OPERATOR'S MANUAL

The operator's manual was clear, well written and contained much useful information on operation, servicing, adjustments, and safety procedures.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the John Deere 510 during 100 hours of field operation while baling about 191 ha (472 ac). The intent of the test was functional evaluation. The following failures represent only those, which occurred during functional testing. An extended durability evaluation was not conducted.

TABLE 5. Mechanical History

Item	Operating Hours	Equivalent Number of Bales
Bale Forming Belts		
-The splicing on a bale forming belt failed at	18	100
-This recurred at	21 & 73	117 & 407
-The lower belt guide bracket weld failed and was rewelded at	30	167
Platform Belts		
-The left platform belt turned inside-out and was repositioned at	30	167
-This recurred at	70 & 99	390 & 552

DISCUSSION OF MECHANICAL PROBLEMS

Bale Forming Belts: The splicing pulled out of individual bale forming belts on three occasions. Splicing failure was probably the result of high impact loads when discharging heavy bales. Modifications to reduce splice failures during bale discharge are recommended.

The lower belt guide bracket weld failed due to poor weld penetration. Once repaired this problem did not recur.

Platform Belts: The left platform belt turned inside out on three occasions. No cause was determined. Repositioning the belts was difficult due to the endless belt construction.

APPENDIX I
SPECIFICATIONS

MAKE:	John Deere Round Baler
MODEL:	510
SERIAL NUMBER:	355624E
MANUFACTURER:	John Deere Otumwa Works Ottumwa, Iowa 52501 U.S.A.
OVERALL DIMENSIONS:	
-- width	2438 mm (96.0 in)
-- height	2785 mm (109.6 in)
-- length	4170 mm (64.2 in)
TIRES:	
--size	2, 11L x 14, 6-ply
WEIGHT: (With drawbar in field position and two balls of twine)	
-- left wheel	716 kg (1579 lb)
-- right wheel	702 kg (1548 lb)
-- hitch point	316 kg (696 lb)
Total Weight	1734 kg (3823 lb)
BALE CHAMBER:	
-- width	1600 mm (63.0 in)
-- maximum diameter	1900 mm (74.8 in)
-- tension method	spring
PLATFORM BELTS:	
-- number of belts	7
-- belt width	203 mm (8.0 in)
-- thickness	6 mm (0.24 in)
-- spacing (centre to centre)	229 mm (9 in)
-- belt speed (at 540 rpm)	2.05 m/s (80.8 in/s)
FORMING BELTS:	
-- number of belts	9
-- belt width	102 mm (4.0 in)
-- thickness	5 mm (0.20 in)
-- spacing (centre to centre)	170 mm (6.7 in)
-- belt speed (at 540 rpm)	2.16 m/s (85.0 in/s)
BALE SIZE INDICATOR:	mechanical linkage
COMPRESSION ROLLERS:	
-- number of rollers	2
-- roller surface	
-upper	rubber
-lower	rubber (platform belt drive roller)
-- length	1535 mm (60.4 in)
-- diameter	
-upper	210 mm (8.3 in)
-lower	180 mm (7.1 in)
PICKUP:	
-- type	floating cylindrical drum with spring teeth
-- height adjustment	adjustable hand crank
-- width	1555 mm (61.2 in)
-- diameter	330 mm (13.0 in)
-- number of tooth bars	4
-- tooth spacing	65 mm (2.6 in)
-- speed (at 540 rpm PTO)	115 rpm
TWINE SYSTEM:	
-- capacity	2 balls
-- recommended twine size	none
-- twine feed	hydraulic
-- twine cutter	hydraulic
SAFETY DEVICES:	Adjustable power take-off slip clutch, automatic pickup release when bale full, rear gate cylinder lock, totally enclosed power take-off.
SERVICING:	
-- grease fittings	3, every 30 hours
-- chains	5, every 10 hours
-- wheel bearings	2, yearly
-- gearbox	1, yearly

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

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

APPENDIX III
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 hectare (ha)	= 2.47 acres (ac)
1 kilometre/hour (km/h)	= 0.62 miles/hour (mph)
1 tonne (t)	= 2204.6 pounds (lb)
1 tonne/hour (t/h)	= 1.10 ton/hour (ton/h)
1 tonne/hectare (t/ha)	= 0.45 ton/acre (ton/ac)
1000 millimetres (mm) = 1 metre (m)	= 39.37 inches (in)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 kilogram (kg)	= 2.20 pounds (lb)
1 tonne/kilowatt hour (t/kW•h)	= 0.82 tons/horsepower hour (ton/hp•h)

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