FERIC FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

TN # 46

Interior Limbing, Bucking and Processing Study

Evaluation of Barko 450 Loader

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Technical Note No. TN-46

July 1981

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ACKNOWLEDGEMENTS

FERIC wishes to thank personnel from the following companies for their assistance and cooperation during the study of the Barko 450 loader:

Crown Zellerbach Canada Ltd., Kelowna, B.C.
Duncan Logging, Kelowna, B.C.
Wajax Equipment Ltd., Vancouver, B.C.

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SUMMARY

The Barko 450 Loader represented a modification to the central processing yard system reported in FERIC's Technical Report No. TR-45. The machine had replaced a Caterpillar 966C front-end loader working at the bush landings.

The machine is a track-mounted hydraulic knuckle-boom loader equipped with a 360° rotating grapple. The grapple (designed primarily for loading tree-length wood) features two outriggers (or live heels) for load levelling. The machine weighs approximately 30 000 kg and the purchase price is between $235,000 and $240,000.

Wood from two areas was loaded during the study period. The first area was logged by feller buncher and grapple skidder, with full trees piled at roadside for loading. Average tree size equalled 0.3 m^3 and the major species harvested was lodgepole pine. In 32 days the Barko 450 loaded 20.5 million kg, with a volume of 21 057 m^3, for 349 off-highway truck loads. The average volume per truck load was 60.3 m^3 and the loader produced an average of 658 m^3 per shift.

The second area in the study was hand felled and cable yarded with a Washington 78 yarder. The full trees (average tree size equalled 0.8 m^3) had been piled along roadside. The Barko loaded on to off-highway trucks. Some 5.6 million kilograms (or 7 194 m^3 in volume) of wood was loaded onto 115 trucks in 11 days. Average volume per load for the trucks was 62.6 m^3 and the daily loader production averaged 654 m^3.

In both areas, the loader worked well. There were few repairs and machine availability averaged 96%. Machine utilization averaged about 79%. The difference (17%) reflected the amount of time spent waiting for trucks, moving between loading areas, sorting and decking logs. Improving machine utilization would increase production and lower loading costs, but this would require a more constant supply of logs and trucks. For the ground skidding area of this study, daily production was limited to about 700 m^3 (or 12 off-highway truckloads) and so no improvement in loader performance was possible. The Note discusses some areas where design changes to the operator's cab are necessary. It also provides some general observations on the loader operation during the study.

BARKO 450 LOADER

INTRODUCTION

This Technical Note describes the use of the Barko 450 loader at two different operations, a ground skidding area and a cable yarder setting. Productivity figures come from both shift level and detailed timing studies for both areas. The Barko uses a rotating grapple with live heels which allow it to load multiple stems each pass, in contrast to the normal heel-boom loader.

TECHNICAL DESCRIPTION

This machine is a hydraulic knuckle-boom loader (see Figure A.) It is mounted on a Chaptrac hydraulic undercarriage model 500 and is equipped with a Weldco model XG-125 360° rotating grapple. The loader has a horizontal reach of 10.1 metres and a lifting capacity of 23 600 kg at 3-metre radius. The boom and cab assembly has continuous 360° swing capability, and the cab is equipped with joy-stick controls. The grapple also has a 360° continuous rotation and a 4.5 m^3 capacity. It is equipped with live heels on each side of the grapple for controlling the logs during loading (see Figure B.) The undercarriage is equipped with the EXPANDO feature allowing the width to be increased hydraulically from 3.7 m to 4.3 m to improve stability during loading. The undercarriage has travel speeds up to 3.2 km per hour.

More details of the machine specifications are presented in Appendix I.

The machine weighs about 30 000 kg, and the purchase price is currently between $235,000 and $240,000.

FIGURE A. Barko 450 Loader. Loading skidder wood from roadside decks.

FIGURE B. Close-up view of grapple. Note the chain drive for 360^{o} grapple rotation and the two hydraulic live heels.

Details of Operation

The loader worked at two different locations during the study period. The first of these was a feller-buncher and grapple-skidder operation in stands of small pine. The logs were piled at roadside (see Figure C) and loaded onto off-highway trucks. The truck haul was about 35 km to the Peachland yard, a central processing area. Here the full trees were limbed, bucked and topped using a Hahn Harvester and also a flail with manual bucking and topping. The processed logs were then reloaded and trucked on-highway to the mill. This operation (excluding the Hahn Harvester) is described in more detail in FERIC's Technical Report No. TR-45*. Piece size averaged 0.31 m^3 per log.

The second area consisted of a cable yarder operation located to the west of Kelowna. The stands of spruce and balsam fir were manually felled, and yarded to roadside by a Washington 78 cable yarder (see Figure D). After loading by the Barko, full trees were hauled by off-highway trucks for about 30 km to the 4-Mile yard, a central processing area. Here the trees were flail or manually limbed, bucked, topped and then reloaded for a short 8-km haul, again off-highway, to a water dump on Okanagan Lake. Piece size averaged 0.8 m^3 per log.

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*"Comparison of Two Logging Operations in Interior British Columbia: Central Processing Yard vs Conventional", by I.B. Hedin, FERIC Technical Report No. TR-45, November 1980.

FIGURE C. Loading small pine logs from roadside piles on the skidder operation. Loader is working on a level site beside the road. The elevated position gives good visibility for loading off-highway trucks.

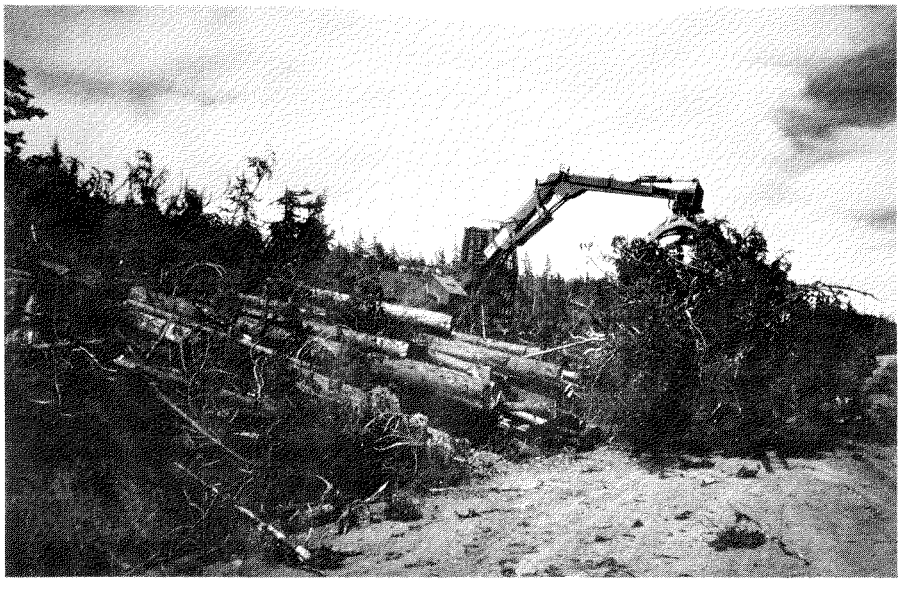


FIGURE D. Loading spruce and balsam trees from roadside on the yarder operation. Note the larger tree size and branchier material.

Study Results

Table 1 shows the results of the shift-level monitoring of the Barko 450 Loader for September and October 1980.

TABLE 1. Summary of Shift-Level Monitoring

	Skidder Wood to Peachland Yard	Yarder Wood to 4-Mile Yard
Shifts reported	32	11
Shifts worked	32	11
Scheduled machine hours	335.7	124.1
Productive machine hours	267.4	97.8
Repair hours	3.1	
Service hours	9.6	3.3
Non-mechanical delays	55.6	23.0
Machine availability*	96.2	97.3
Machine utilization	79.7	78.8
Number of trucks loaded	349	115
Total weight loaded	20 542 990 kg	5 635 330 kg
Equivalent volume**, m^3	21 057 m^3	7 194 m^3
Average truck load weight	58 862 kg	49 003 kg
Average truck volume	60.3 m^3	62.6 m^3
Loader productivity - m^3/PMH	78.7	73.6
- m^3/shift worked	658.0	654.0

*The high levels of machine availability reflect the fact that the machine was very new. It is expected that availability will decrease to a more normal level (around 80 to 85%) as the number of hours worked increases.

**Equivalent volume calculated using pertinent conversion factors from scaled loads.

Work sampling was carried out at both locations to give more details of the loader activities for both skidder and yarder wood. Table 2 shows this breakdown of loader activities.

TABLE 2. Breakdown of Loader Activity

	Skidder Wood to Peachland Yard	Yarder Wood to 4-Mile Yard
Truck Present	% of Time	% of Time
Preparation of trailer before and after loading	10	13
Loading	28	50
Adjusting logs on load	4	12
Delays during loading (incl. move, sorting, cleaning etc.)	7	16
No Truck Present		
Productive (move, sort, etc.)	21	4
Maintenance and repair	13	-
Idle	12	3
Talk to foreman	5	2
TOTAL	100	100

Table 3 compares details of the loading in the two areas.

TABLE 3. Results from Detailed Timing Samples

	Skidder Wood	Yarder Wood
Average time to load truck	32 minutes	50 minutes
No. of cycles to load truck*	25	42
No. of logs per load	200	88
Average volume per load**	62.6 m^3	63.4 m^3
Average piece size	0.31 m^3	0.73 m^3
Average loading time per m^3	0.51 minutes	0.79 minutes
Average load weight	61 021 kg	48 854 kg
Average loading rate, kg per minute	1 920	970

*A cycle involves the following: swing from truck to pile, picking up log(s) from pile, swinging back to truck with log(s) and placing log(s) on load.

**Different conversion factors were used for the two areas to reflect the different types and qualities of wood processed in the yards.

Comparison with Front-End Loader

From Hedin's study of a central processing yard logging system, loading in the bush landings with a Caterpillar 966C front-end loader gave different results for winter and summer.

In winter, average time to load an off-highway truck was 22 minutes per load, with an average load volume of 69.5 m^3. In summer, a 60.2 m^3 load was assembled in 45 minutes. Most of this difference was attributed to the inexperience of the summer operator.

This operator switched to the Barko loader when it replaced the Caterpillar 966C for loading the skidder wood at Peachland. From Table 3 we see that his loading time with the Barko 450 was 32 minutes per load of 62.6 m^3. These results show an improvement in operator performance as experience increased, and indicates also that the two machines have equivalent loading rates.

The front-end loader has a lower purchase price than the Barko. It requires a landing to function efficiently, and the landing requires good supervision to ensure a smooth flow of wood through it. The Barko can operate from roadside piles without a need for landings. More wood can be decked at roadside than can be stored at normal sized landings. This permits cold decking of wood during break up. Also the problems associated with wet muddy landings are avoided. The Barko is more versatile than a regular heelboom loader because of the 360° rotating grapple. For loading yarder wood the Barko shows more promise because it does not need landings. It functions well with both small and large logs. Its major disadvantage occurs with ground skidded wood to landings, when the slow travel speed between landings reduces available loading time per shift.

General Comments

The loader worked well during the period of the study. There were very few repairs made in that time. Therefore machine availability figures are high. A longer study period is necessary to predict a more normal level, expected to be in the 80 to 85% range. The amount of time reported as non-mechanical delay is accounted for by the following activities:

- moving between loading points
- adjusting log piles prior to loading
- preparing positions for loading
- waiting for trucks to arrive at loading points.

All of these activities can be considered as inherent in loader activity. Efforts to improve loader utilization and control loading costs would look at these as areas for improvement. At Peachland, there was no potential for improvement. Loader productivity is limited to 12 off-highway

loads per day. The loader must be there to load these trucks and any idle time between loading is unavoidable. The 12 off-highway loads provide the daily throughput for the yard--250 cunits or 700 m^3.

Logs from the yarder setting were larger than from the skidder shows, 0.8 m^3 compared to 0.3 m^3 per piece. They were piled more haphazardly and the loading area was not level. These points affected the loader in the following ways:

- time was spent by the loader preparing loading points along the roadside.

- from the loading points, it was not always possible to grapple the logs at a point close to the centre of gravity. This made it difficult to free long logs from the piles, especially if tops and branches were intertwined.

- the variety of log lengths required careful selection and placement of the bunk logs on the truck and also of the final logs of the load. Frequently the truck driver assisted with positioning of the final few logs of each load.

- at the beginning of the shift, lights were required. The lighting on the Barko gives good illumination around the grapple and close to the machine. With the long logs from the yarder, there was insufficient illumination of the tops of the logs. The operator, therefore, could not determine if a log was tangled with others and had difficulty extracting such logs from the pile. The addition of a swivelling spotlight on the cab would solve this problem.

- the combined width of an off-highway truck and the loader was greater than the road width. Consequently the loader was often working from a low position straddling the ditch. This gave poor visibility of the logs in the pile and the logs on the truck, as a load neared completion. Slower loading times resulted.

- the live heels were not powerful enough to stabilize long logs unless they had been grappled close to the centre of gravity. This weakness

was particularly evident when loading the yarder wood where the piling had been haphazard.

- the off-highway trucks used "cheater bars" to increase the height of the front stakes. A similar arrangement on the rear stakes would have helped loading of the yarder wood, which was light and required large loads to achieve good load weights for the trucking. The loader spent time adjusting the logs on the load to prevent them from falling off.

Logs from the skidder area were smaller (0.3 m^3 per piece) and more neatly piled along the roadside. The terrain was flatter and the loader had a better working environment. Movement between loading points on the ground skidding show was slow due to the low travel speed of the loader.

A full ergonomic evaluation of the loader was not made. The following comments refer to areas where design improvements are needed to enhance operator safety.

- The flat deck area between the cab door and the top of the access ladder needs a nonslip surface. It is 2.7 m (9 ft) above the ground. Spilled fuel and oil, and ice accumulation in winter, could make the present surface extremely hazardous.

- The operator's seat is adjustable for height and weight of operator. It does not swivel and the operator has to climb over the seat to get into position, using the cab heater as a foot rest. This causes undue wear and tear on the seat. It does not allow the operator to exit quickly in the event of an emergency.

The user company hoped to achieve 3 main objectives by using the Barko 450 loader, as follows:

- improved skidder productivity
- reduction (or elimination) of landing construction
- reduction of tree breakage during loading.

Achievement of these 3 objectives was considered sufficient justification for the higher loading costs and longer loading times expected with the Barko. To date results show

that the first two objectives are being achieved. It is anticipated that the third objective will also be realized, although some breakage was noted when intertwined trees were freed from roadside piles during the loading of yarder wood.

Conclusion

The use of the Barko represented a modification to the central processing yard system, where it replaced a Caterpillar 966C front-end loader working at the bush landings. The Barko handled the required daily volume of wood (up to 700 m^3 per day) efficiently and neatly. It achieved a high level of mechanical availability (96%). In comparison, the 966C front-end loader averaged 835 m^3 per day in winter with an experienced operator, and 540 m^3 in summer with a less experienced operator.

The Barko loader works without landings so trees can be skidded or yarded to roadside piles for loading onto trucks. During the study, it loaded off-highway trucks with both skidder wood and yarder wood at rates of 658 m^3 in a 10.5 hour shift and 654 m^3 in an 11.3 hour shift, respectively. It compares favourably as an alternative to the front-end loader, and also to a heel-boom type loader for yarder wood.

APPENDIX I

DETAILS OF MANUFACTURER'S SPECIFICATIONS

BARKO 450 LOADER

MANUFACTURERS' SPECIFICATIONS AND FEATURES

AVERAGE LIFT CAPACITY (LESS ATTACHMENT)

. 10' radius	56,000 lbs.
. 15' radius	36,000 lbs.
. 20' radius	27,000 lbs.
. 25' radius	21,000 lbs.
. 30' radius	17,000 lbs.

BOOM REACH

- Horizontal--33' 3"
- Vertical--40' 2"
- Total overall height--12'

BOOM DATA

- Main boom length--18'
- Secondary boom length--16'
  Hi-tensile/100,000 PSI yield fabricated tube structure 12" wide x 16" high
- Tapered roller bearing at boom pivot points

SWING SYSTEM

- Rotation continuous on 54" turntable bearing
- Swing speed 6.9 RPM--power transmitted by single piston type motor

CYLINDERS

- Barko built--double acting with extra heavy chromed rods--aircraft aluminum pistons and glands--micro-uniform walled tubing honed to exacting tolerances
- Main boom--twin 7" x 50" with 4" rods
- Secondary boom--twin--6" by 50" with 4" rod

HYDRAULIC SYSTEM

- 180 gallon multi-baffled reservoir with submerged suction and external return line filters
- Control valves--VDP-24 Parker with main system relief and safety port reliefs for each control function
- Pumps--one tandem vane, one single vane and one variable swing pump produce 182 GPM @ 2500 RPM
- Continuous rotation--Barko designed and built hydraulic collector
- Heavy wall tubing and 4-wire braided hose throughout main system
- Operating pressure 2500 PSI

CONTROL DECK

- Central console with engine instrumentation and start/stop controls
- Foot swing controls

OPERATORS CAB

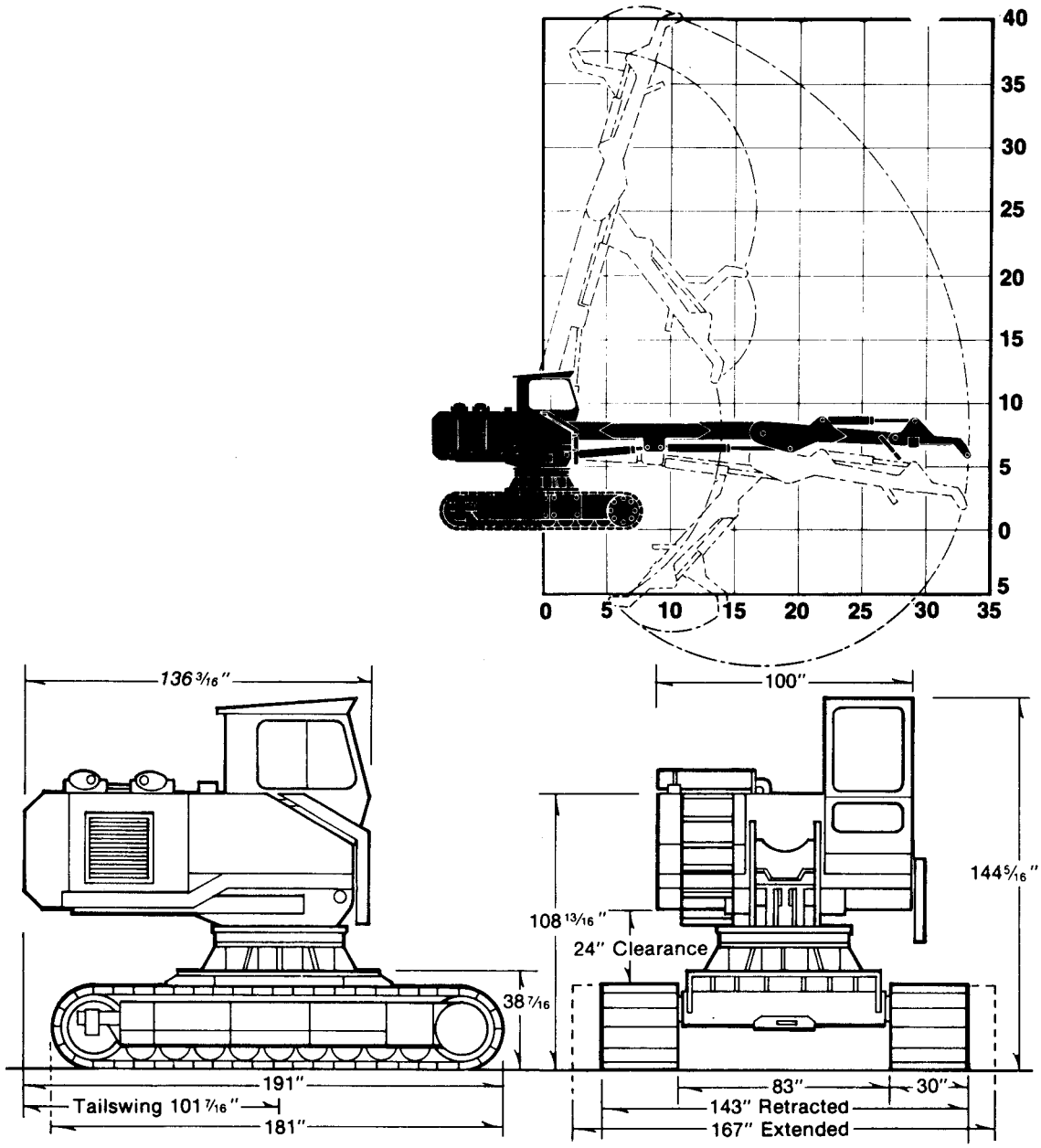
- 50" x 65" with double insulation and roof vent
- Tinted windshield, wiper/washer, defroster fan, heater, dome light, and fire extinguisher
- Weldco guarded cab
- Equipped with joy stick controls and comfort package

POWER SOURCE

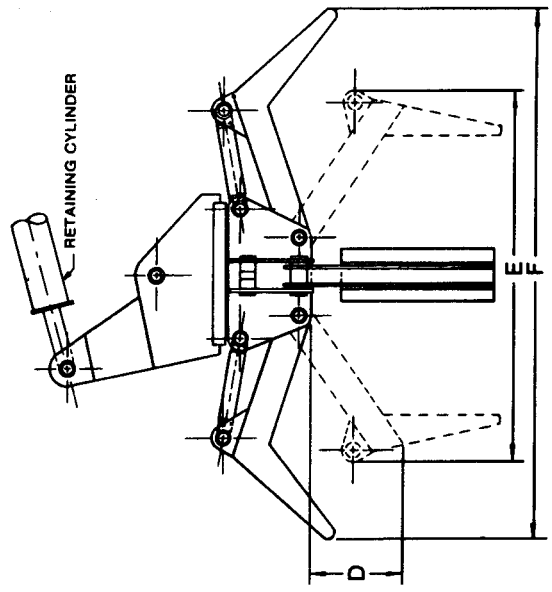
- GM6V-53 diesel 184 HP @ 2500 RPM
- Fuel reservoir--60 gallons

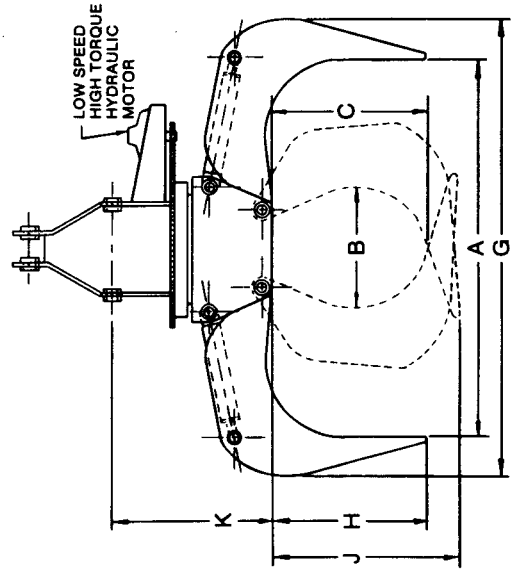
UNDERCARRIAGE (Chaptrac hydraulic undercarriage)

- Expando type--Hydraulically operated
- Width--12' retracted/14' operated
- Length--15' 8"
- Track pads--Tractor type 30" wide 3 bar semi-grouser
- Drive motors--2 speed commercial gear motors
- Final drive--Planetary
- Brakes--Spring apply hydraulic release on each track. (Fail safe)
- Track Tensioner--Nitrogen cylinders with grease release
- Travel speed: low-.7 mph, high-2 mph


40
35
30
25
20
15
10
5
0
5
0
5
10
15
20
25
30
35
136 3/16"
100"
144 5/16"
108 13/16"
24" Clearance
38 7/16
191"
Tailswing 101 7/16"
181"
83"
30"
143" Retracted
167" Extended

Weldco 360° Rotating Grapple





Model	A		B		C		D		E		F		G		H		J		K		Jaw & Stabilizer	Retaining Cylinder	Rotation Output Torque		Rotation	Capacity		Weight	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	Cylinders		in./lb.	Nm		cords	m^3	lbs.	kg
XG 125	62	1575	15	381	24	610	21	533	85	2159	115	2921	72	1829	34	864	39	991	44	1118	5"	5"	147,200	16,576	cont.	1¼	4.5	4000	1814

APPENDIX II

CONVERSION FACTORS

The following conversion factors from Imperial units to S.I. (metric) units are provided because the machine specifications are given in Imperial units.

1 inch	=	2.54 centimetres
1 foot	=	0.3048 metres
1 psi	=	6.8948 kilo Pascals
1 pound	=	0.454 kilograms
1 gallon (US)	=	3.7854 litres
1 horse-power	=	0.746 kilowatts
1 mph	=	1.6093 kilometres per hour
1 gallon/minute	=	0.0631 litres/second