O.E.C.D. Report **N° 665**

Test Bulletin
Tractor

ZETOR 16045

Manufactured by : ZETOR - Brno - Czechoslovakia



Date of tests : October 1978 - July 1979
Date of approval : 7th March 1980

Ministère de l'Agriculture
Station de Génie Rural

146, chaussée de Namur

Gembloux - Belgique

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Tractor manufacturer : ZETOR - BRNO - CZECHOSLOVAKIA
Submitted for test by : Manufacturer
Selected by : Manufacturer with the agreement of the testing station
Place of running-in : Manufacturer
Duration of running-in : approx. 20 hours

SPECIFICATION OF TRACTOR

Tractor :

Make : ZETOR
Model : Four wheel, all wheel driven, unit construction with cab
Type : 16045
Serial n° : 1003

Engine :

Make : ZETOR
Model : 4 stroke Diesel engine, direct injection and turbocharged
Type : Z 8602 Turbo
Serial n° : 00011

Cylinders : Number : 6 - Vertical in line - Bore, stroke : 110-120 mm
Capacity : 6842 cm^3 - Compression ratio : 17/1
Overhead valves - Wet cylinders liners

Fuel system :
Injection pump : MOTORPAL PP6M-85K1d - 2481 in-line
Injection pump + fuel feed pump
Fuel filter : A.B. JABLONEC 03-9800.00 - dual filter with cartridges in paper - recommended change period : 600 hours
Injector nozzles : DOP 150 S 535 4360 - Multihole injection nozzle
Injector pressure : 160 ± 3 bar
Injection timing : 24° + 2° before T.D.C.
Manufacturer's production setting : 78 mm^3/stroke at rated engine speed and full load
Fuel tank capacity : 195 litres

Governor : Make : PAL RV1M 225/1100-2501
Type : Mechanically operating variable speed type governor incorporated in injection pump
Governed range of engine speed : 550/2420 rev/min
Rated engine speed : 2200 rev/min

Turbocharger :
HOLSET - 3 LD 9/2,4
Exhaust driven

Air cleaner :
Make : IFE MANN 750 - Oil bath
Oil capacity : 2,1 litres
Centrifugal precleaner - PC 750

Exhaust silencer :
Own make
Chambre-expansion type silencer
On the left side of the bonnet, mouth upwords
101x196 mm oval, 705 mm long
Mouth 2495 mm above ground

Lubrication system :
Type : forced feed from gear type pump - Heat exchanger before the centrifugal filter
Type of oil filter : RDP 3 A centrifugal
Recommended cleaning period : 200 hours
Oil capacity : 18 litres
Recommended oil change period : 200 hours
Recommended oil : in summer : SAE 20 W/30
in winter : SAE 10 W/30
the whole year : 10 W/40
Quality : MIL-L-45199 B
A.P.I. : CD

Cooling system :
Water cooling, pressurized - belt driven fan with 4 blades, Ø 460 mm
Pump : centrifugal
Temperature control : thermostat and thermometer on the instrument panel
Cooling water capacity : 25 litres (with heating)
Pression : 0,4 $\pm$ 0,1 bar

Starting system :
Electrical - Type : 24 V - 4,4 kW
Solenoïd engaged type

Electrical equipment :
Voltage : 12 V (24 V for the starting system)
Alternator : PAL MAGNETON - 14 V - 35 A
Battery : 2 batteries 6 N 100 of 12 V and 100 Ah at 20 hours rating

Transmission :

Clutch : Make : ZETOR
Type : dry disc single type clutch
External diameter : 380 mm
Foot-pedal operated

Gear box : Make : ZETOR
Type : 3 gear box, group gear with 2 forward and 1 reverse group, torque amplifier, all handlever operated
Number of speeds : 12 forward and 6 reverse speeds
Oil cooler placed before the cooling system

Rear axle and final drive :
Make : ZETOR
Type : crown wheel and pinion, bevel gear and differential, planetary reduction final drive
Differential lock, foot-pedal operated, self-disengaging

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Driven front axle and final drive :

Make : ZETOR
Type : crown wheel and pinion, bevel gear and differential without locking
Driven by the gearbox by an universal joint shaft
Engaging and disengaging with sliding handle operated hydraulic clutch
Planetary final drives in the front wheels

Oil capacity :

Gearbox, rear axle and power lift : 55 litres
Oil changing period : 1200 hours
Recommended oil : SAE 80 - Quality : A.P.I. : GL 4
Driven front axle : 3,5 litres (SAE 90) - Quality : A.P.I. : GL 4
Front planetary final drives : 3,5 litres (SAE 90) - Quality : A.P.I. : GL 4

Gear n°	Number of engine revolutions for one revolution of the driving wheel	Nominal travelling speed at rated engine speed and with 18,4/15-34 tyres °) km/h
Forward		
1 B - A °°)	286,91	2,20
1 B	214,46	2,94
2 B - A	176,10	3,58
2 B	131,63	4,79
3 B - A	104,98	6,00
1 H - A	91,54	6,89
3 B	78,47	8,03
1 H	68,42	9,21
2 H - A	56,19	11,22
2 H	42,00	15,01
3 H - A	33,50	18,82
3 H	25,04	15,17
Reverse		
1 A	244,11	2,58
1	182,46	3,45
2 A	149,83	4,21
2	112,00	5,63
3 A	89,32	7,06
3	66,76	9,44

°) Calculated with tyre rolling radius of 760 mm
°°) A = Torque amplifier in power position

Power take-off :

Independent p.t.o. :
At rear of tractor in median plane
Driven through a hand lever hydraulicaly operated multiplate clutch
624 mm above ground (with 18,4/15-34 tyres)
Distance of p.t.o. - end to rear axle centre : 510 mm

Power take-off - 1000 rev/min :
Replacable p.t.o.-end
45x40x3,3 mm, 20 splines
1012 rev/min at rated engine speed (2200 rev/min)
Standard p.t.o. speed 1000 rev/min at 2174 rev/min engine speed
Direction of rotation : clockwise viewed from tractor rear

Power take-off - 1000 rev/min :
29x31,8x2,5 mm, 21 splines (ISO R 500)
1012 rev/min at rated engine speed (2200 rev/min)
Standard p.t.o. speed 1000 rev/min at 2174 rev/min engine speed
Direction of rotation : clockwise viewed from tractor rear
Maximum permissible torque at 1000 rev/min : 785 Nm
Maximum permissible power at : 1000 rev/min : 82 kW

Proportional ground speed power take-off :
Travelling distance for one revolution of the p.t.o. shaft : 0,174 m
27,4 revolutions of the p.t.o. shaft for one revolution of the driving wheel
Direction of rotation : clockwise viewed from tractor rear when travelling forward

Power lift :

Make : ZETORMATIC
Type : single acting ram
Position control, draft control by lower links and mixing control
Gear type pump driven by transmission in the clutch housing in amount of p.t.o. clutch - disconnecting drive
2 auxiliary acting rams : bore : 50 mm - stroke : 287 mm
Auxiliary power lift pump : driven by an eccentric on the p.t.o. shaft
Recommended oil : SAE 80 - Quality : A.P.I. : GL 4
Type of filter : strainer and paper element filter
Recommended oil change period : 1200 hours
Oil capacity : 55 litres (transmission oil), 15 l may be taken off through oil tappings
External tappings : 2

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Implement linkage :

Three point implement linkage, ISO R 730, category 3, operated by power lift
Lifting rods length adjustable from 540 to 640 mm (right)
544 to 684 mm (left)
Lifting range above ground with :
lifting rods short : from 219 to 975 mm
lifting rods long : from 30 to 785 mm

Holed drawbar :

Type : double bar with 9 holes of 32 mm diameter, 80 mm distance each
Tickness of the bar : 20 mm - width : 100 mm
Length between the joint balls : 1010 mm
Heigt above ground ajustable by power lift from 76 to 1011 mm, measured at the surface of the drawbar
With lower links in horizontal position :
horizontal distance of centre hole to rear axle centre : 1083 mm
horizontal distance of centre hole to p.t.o. shaft end : 573 mm

Pull attachment :

1) Trailer hitch :
At rear of tractor
Height above ground adjustable in four positions : 676, 726, 776 and 826 mm
Diameter of coupling pin : 30 mm
Horizontal distance of hole from rear axle centre : 863 mm
Distance of hole from p.t.o. shaft end : 353 mm behind - 52, 102, 152 and 202 mm above
Maximum static downward load : 1000 kg

2) Towing hitch :
At front of tractor
Height above ground : 902 mm
Diameter of coupling pin : 30 mm

Swinging drawbar :

Location : at rear of tractor
Height above ground : 452 mm
Horizontal distance of hole from rear axle : 910 and 1010 mm
Horizontal distance of hole from p.t.o. shaft end : 500 - 410 mm
Lateral adjustment : 160 mm (to either side)
Pivot position relative to rear axle : 305 mm to front
Diameter of pin : 30 mm
Maximum static downward load : 700 kg

Steering :

Make : PILMET WROCLAW - Recirculating ball type
Steering wheel operated
Type : with universal joint shaft
Hydraulically power assisted - Number of cylinders : 1
Pump delivery : 10 l/min at 1200 rev/min of the engine - Max. pressure : 82,4 + 8 bar

Brakes :

a) Foot brake :
Make : ZETOR
Type : discs brackes on differential shafts
Diameter of discs : 227 mm
Hydraulically acting
Operated by the single parts of the divided pedal of foot brake; for normal use both parts are connected together

b) Parking brake :
Type : mechanically acting on discs of service brakes
Operated by a handlever with locking ratch

Wheels :

Steering wheels : Number : 2 - Location : at front
Type of tyres : 14,9/13-24; 8 ply - diagonal carcass
Maximum permissible load on each tyre : 1630 kg at 1,6 bar inflation pressure and 30 km/h velocity
Track width : 1710 mm
Rims : W 12 x 24

Driving wheels : Number : 4 - Location : at front and in the rear
At front : see steering wheels
At rear : type of tyres : 18,4/15-34; 8 ply, radial carcass
Maximum permissible load on each tyre : 2565 kg at 1,4 bar inflation pressure and 30 km/h velocity
Track widht: 1500 and 1725 mm
Changed by turning wheels
Rims : W 15 x 34

Wheel base : 2695 mm

Lighting :

Unrestricted beam angle of headlights in plan view : 22 mm/m

	Height above ground of centre	Size	Distance from outside edge of tractor to centre at 1725 mm track
	mm	mm	mm
Head lights	1188	Ø 123	943
Side lights	1748	40x55	70
Rear lights	1382	106x74	284
Reflectors	825	Ø 80	115

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Number of grease points :

Whole tractor : 15

CONDITIONS DURING TEST

Masses :

Tractor without driver but with tanks full and cab

	Front	Rear	Total
	kg	kg	kg
Without ballast	1969	3021	4990
With ballast	2363	4264	6627

Ballast :

	Number of mass	Total wight (without water)	Water
		kg	kg
Front end	3	75	300
Rear wheels	16	560	702

Track setting during tests :

Front : 1710 mm
Rear : 1725 mm

Overall dimensions :

Length : 4533 mm, without ballast (lower links - front of bonnet)
4763 mm, with ballast (lower links - front ballast)

Width : 2190 mm, with or without ballast and at 1725 mm track

Height : 2495 mmn to top of exhaust pipe
2480 mm, to top of cab

Ground clearance : 392 mm (pivot of swinging drawbar)

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Seat :

Make : ZETOR
Type : upholstered seat with back rest and elbow-rests
Type of suspension : parallelogram linkage
Type of shock absorber : hydraulic and pneumatic shock absorber
Adjustment : in length direction : 225 mm
in height : none

FUEL AND LUBRICANTS USED IN TESTS

Laboratory tests :

Fuel : type : SHELL diesel-fuel
Density : 0,840 kg/l at 15°C

Engine oil : type : SHELL Rimula CT
Viscosity : SAE 20W/30

Transmission oil : OA-PP 80
Viscosity : SAE 80

Drawbar tests :

Fuel : type : SHELL diesel-fuel
Density : 0,840 kg/l at 15°C

Engine oil : type : SHELL Rimula CT
Viscosity : SAE 20W/30

Transmission oil : OA-PP 80
Viscosity : SAE 80

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COMPULSORY TESTS

I. MAIN POWER TAKE-OFF PERFORMANCE

Date and location of tests : 23.10.1978 - GEMBLOUX
Type of dynamometer : electrical SCHENCK W 780

Power	Speed		Fuel consumption		
	Engine	P.t.o.	Total	Specific	Specific energy
kW	rev/min	rev/min	l/h	g/kW h	kW h/l
At maximum power - 2 hours test					
105,1	2200	1012	30,354	243	3,46
At standard p.t.o. speed (1000 rev/min)					
104,8	2174	1000	30,329	243	3,46
At the speed recommended by the manufacturer for drawbar work					
105,1	2200	1012	30,354	243	3,36
Fuel consumption at part loads					
I) 85% of torque at maximum power					
92,8	2285	1051	27,660	250	3,36
II) Unloaded					
-	2431	1118	7,973	-	-
III) 50% of the load defined in (I)					
47,8	2354	1083	17,270	303	2,77
IV) Maximum power					
105,1	2200	1012	30,354	243	3,46
V) 25% of the load defined in (I)					
24,3	2394	1101	12,245	423	1,98
VI) 75% of the load defined in (I)					
70,6	2320	1067	22,465	267	3,14

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No load maximum engine speed : 2431 rev/min

Torque °) at maximum power : 456 Nm

Maximum torque : 492 Nm at 1650 rev/min of the engine

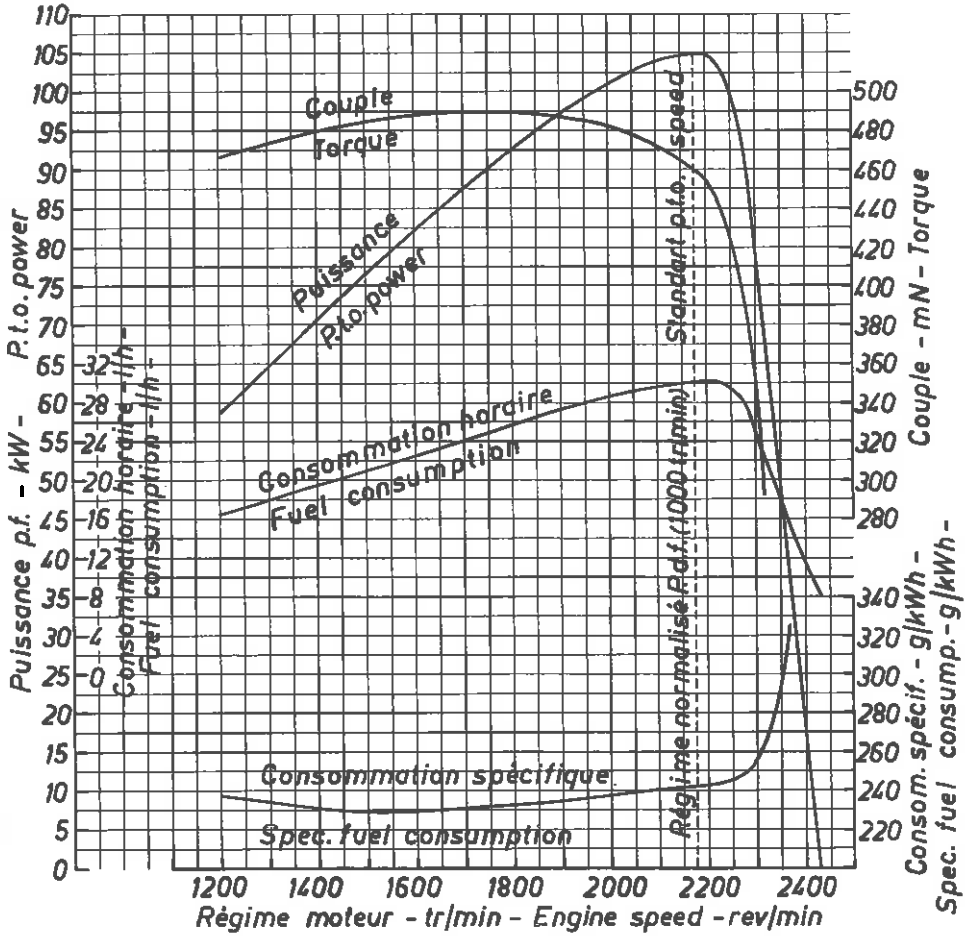
Mean atmospheric conditions :
- temperature : 20°C
- atmospheric pressure : 1004 m bar
- relative humidity : 94 %

Maximum temperatures :
- coolant : 80°C
- engine oil : 92°C
- fuel : 26°C

°) The torque is the equivalent crankshaft torque

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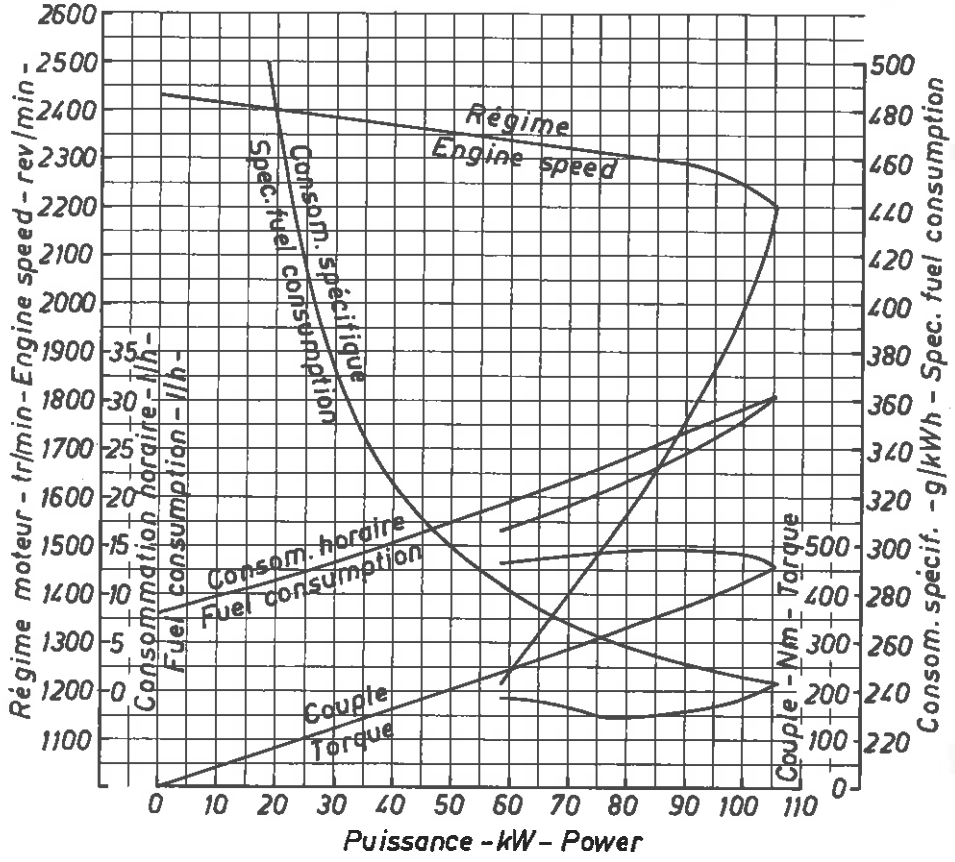
Essais au banc à la prise de force
Power take - off test



Tracteur : *ZETOR 16045*	*Accouplement :* *prise de force*	*Date épreuve :* *23 - 10 - 1978*
Moteur : n° 00011	*T° de l'air : 20° C*	*STATION DE GENIE RURAL C.E.M.A.G. -Gembloux*
Combustible : dens.: 0,840 à 15° C	*Pression barom. : 1004 mbar*	

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Essais au banc à la prise de force
Power take - off test



Tracteur : *ZETOR 16045*	*Accouplement :* *prise de force*	*Date épreuve :* *23 - 10 - 1978*
Moteur : n° 00011	*T° de l'air : 20° C*	*STATION DE GENIE RURAL C.E.M.A.G. - Gembloux*
Combustible : *dens.: 0,840 à 15° C*	*Pression barom. :* *1004 mbar*	

II. DRAWBAR PERFORMANCE ON A CONCRETE TRACK

Date of tests : May and June 1979
Type of track : concrete
Height of drawbar above ground : tractor with ballast : 769 mm
tractor without ballast : 851 mm
Type size : front : 14,9/13-24, 8 ply - inflation pressure : 1,2 bar)
rear : 18,4/15-34, 8 ply - inflation pressure : 1,2 bar) for all tests

Gear n° and group	Speed	Power	Drawbar pull	Engine speed	Slip of wheels	Consumption		Temperatures			Atmospheric conditions		
						Specific energy	Specific fuel consumption	Fuel	Coolant	Engine oil	Temperature	Relative humidity	Atmospheric pressure
	km/h	kW	N	rev/min	%	kW h/l	g/kW h	°C	°C	°C	°C	%	m bar
I) MAXIMUM POWER (ballasted)													
1B-A	2,02	30,2	53660	2385	15,0	-	-	21	80	86	18	65	1008
1B	2,60	38,7	53660	2354	15,0	2,0	398	21	80	86	18	65	1008
2B-A	3,20	47,6	53560	2328	15,0	2,2	378	22	80	86	19	67	1008
2B	4,38	65,1	53560	2309	15,0	2,5	332	22	82	87	18	67	1008
3B-A	5,36	79,6	53560	2279	15,0	2,6	317	22	82	87	18	67	1008
1H-A	6,08	85,0	50330	2217	11,1	2,7	306	22	82	88	19	67	1008
3B	7,06	88,3	45030	2207	9,1	2,8	296	22	83	88	19	67	1008
1H	8,71	93,2	38550	2206	7,1	3,0	280	22	83	88	19	67	1008
2H-A	10,51	96,2	32960	2202	6,1	3,1	273	22	83	88	19	67	1008
II) FIVE HOURS TEST at 75% of pull at maximum power													
1H-A	6,83	71,6	37760	2311	7,3	2,7	310	24	85	90	20	66	997
III) FIVE HOURS TEST at pull corresponding to 15% wheelslip in test (I)													
3B-A	-	-	53560	2280	-	-	-	26	87	91	23	78	997

Total oil consumption during ten hours duration of tests (II) and (III) : 19 g/h

Gear n° and group	Speed	Power	Drawbar pull	Engine speed	Slip of wheels	Consumption		Temperatures			Atmospheric conditions		
						Specific energy	Specific fuel consumption	Fuel	Coolant	Engine oil	Temperature	Relative humidity	Atmospheric pressure
	km/h	kW	N	rev/min	%	kW h/l	g/kW h	°C	°C	°C	°C	%	m bar
IV) MAXIMUM POWER (tractor without ballast)													
1B-A	2,03	24,2	42970	2402	15,0	-	-	26	80	88	24	76	1005
1B	2,72	32,5	42970	2370	15,0	-	-	26	80	88	24	76	1005
2B-A	3,20	38,2	42970	2348	15,0	-	-	26	80	88	24	76	1005
2B	4,33	51,7	42970	2326	15,0	-	-	26	81	89	24	76	1005
3B-A	5,46	65,2	42970	2304	15,0	-	-	27	81	89	24	76	1005
1H-A	6,18	73,6	42870	2278	15,0	-	-	27	81	89	24	76	1005
3B	7,45	83,0	40120	2241	11,5	-	-	27	82	90	24	76	1005
1H	8,31	88,3	38260	2200	10,2	-	-	27	82	90	24	76	1005
2H-A	10,51	91,3	31290	2198	6,7	-	-	27	82	90	24	76	1005

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III. TURNING SPACE AND TURNING CIRCLE

Wheel equipment : front : 14,9/13-24, 8 ply
rear : 18,4/15-34, 8 ply

Track of wheels : front : 1710 mm
rear : 1725 mm

	With brakes		Without brakes	
	Right hand	Left hand	Right hand	Left hand
	m		m	
With all-wheel drive				
Radius of turning space	4,58	4,72	6,23	6,35
Radius of turning circle	4,40	4,54	6,05	6,17
With rear-wheel drive				
Radius of turning space	4,89	4,83	6,72	6,81
Radius of turning circle	4,71	4,65	6,54	6,63

IV. LOCATION OF CENTRE OF GRAVITY

Height above ground	820 mm
Distance forward from the vertical plane containing the axis of the rear wheels	1055 mm
Distance of the medium plane of the tractor	5 mm to the left

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V. BRAKE TESTS

Date of tests : 18.04.79 and 18.06.79
Type of track : concrete
Type of decelerometer : MOTO-METER, recording type
Masse of ballasted tractor : 6627 kg without driver

COLD BRAKES

	With ballast	Without ballast
Travelling speed - km/h	25	25
Deceleration - m/s^2	4,1	4,2
Stopping distance - m	7,3	7,2
Force on pedal - N	559	491
Force on pedal to achieve a deceleration of 2,5 m/s^2 - N	294	235

BRAKES FADE CHARACTERISTICS (hot tests)

	With ballast	Without ballast
Deceleration : hot/cold x 100 - %	109	110
Stopping distance : cold/hot x 100 - %	96	97
Force on pedal : cold/hot x 100 - %	93	94

PARKING BRAKE

Tractor facing up slope (16%) :
Pull on hand brake : 225 N, tractor does not roll

Tractor facing down slope (16%) :
Pull on hand brake : 245 N, tractor does not roll

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VI. MEASUREMENT OF AMBIANT NOISE EMITTED BY THE TRACTOR

Date of test : 30.11.78
Type of track : concrete
Type of sound level meter : BRUEL & KJAER, type 2203

Results of test :
Gear : 3 H
Travelling speed before acceleration : 20,75 km/h
Sound level : 86 dB(A)

VII. NOISE MEASUREMENT AT THE DRIVER'S EAR

Date of tests : 30.11.78
Type of track : concrete
Type of sound level meter : BRUEL & KJAER, type 2203
Type of octave filter : BRUEL & KJAER, type 1613
A cab was fitted on the tractor

Results of tests :

Gear n°	Travelling speed km/h	dB(A)	Sones
1B-A	2,23	84	45,8
1B	2,95	84,5	50
2B-A	3,52	83,5	45,8
2B	4,17	84,5	45,9
3B-A	5,93	83,5	43,1
1H-A	6,62	85,5	47,3
3B °)	7,16	85,5	50,6
1H	8,84	85	49,5
2H-A	10,25	84,5	45,7
2H	15,40	84,5	42,1
3H-A	19,20	84	44,7
3H °°)	27,16	84	44,4

°) The 3B gear corresponds to the travelling speed nearest to 7,5 km/h.
°°) With light load.

VIII. POWER LIFT AND HYDRAULIC PUMP PERFORMANCE

Date and location of tests : 12 and 19.07.79 - Gembloux
Hydraulic fluid : viscosity : SAE 80
Type of linkage lock for transport : hydraulically acting linkage lock

HYDRAULIC PUMP

A. Principal circuit of power lift :

1) Opening pressure of relief valve : 134 bar
Sustained pressure by open relief valve : 169 bar

2) Pump delivery rate at minimum pressure and maximum engine Speed : 35 l/min

3) Pump delivery rate : 34,8 l/min
Delivery pressure : 154 bar
Hydraulic power : 8,7 kW

B. Remote circuit :

Same characteristics as principal circuit

C. Auxiliary delivery pump :

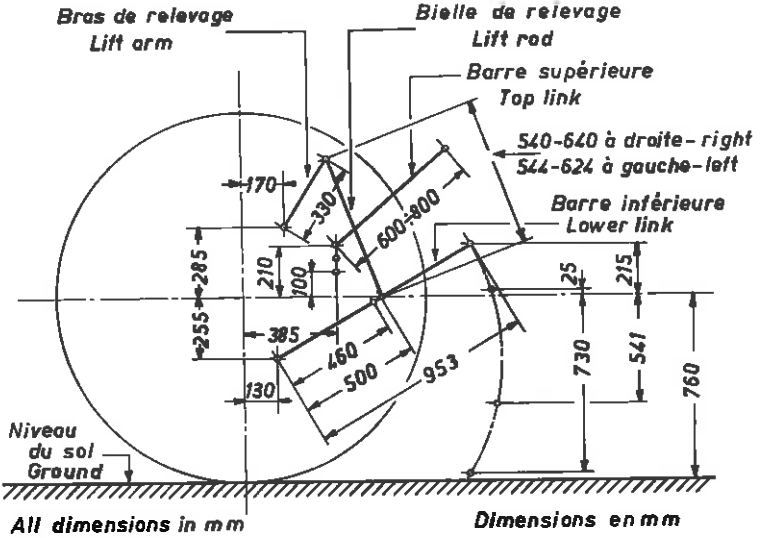
At 1000 rev/min of p.t.o. :

Pump delivery rate : 3,8 l/min
Delivery pressure : 176 bar
Hydraulic power : 1,1 kW

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POWER LIFT

Dimensions of linkage geometry for the table on page 23.



LIFTING FORCES

Lifting heights relative to horizontal lower links

mm	-475	-400	-300	-286	-200	-100	0	+100	+200	+280	+300	+400	+470
At hitch points °)													
Maximum mechanical advantage													
N				49540	49690	49830	49980	50030	50030		49790	48950	48070
Minimum mechanical advantage													
N	49540	49490	49390		49250	49000	48460	48020	47770	47730			
Max. force exerted throughout the whole range : 48070 N/47730 N Force at which front of tractor lifts with maximum allowable front ballast : - N °°) Oil pressure : 169 bar													

mm	-311	-300	-253	-200	-100	0	+100	+200	+300	+351	+400	+500	+533
At test frame °)													
Maximum mechanical advantage													
N	50380	50380		50190	49990	49400	47150	43520	40670	39890			
Minimum mechanical advantage													
N			49110	48910	48520	47730	45480	42340	38610		36160	34690	34390
Max. force exerted throughout the whole range : 39890 N/34390 N Force at which front of tractor lift with maximum allowable front ballast : - N °°) Oil pressure : 169 bar													

°) All values of forces for pressure at max. hydraulic power calculated from measurements at maximum oil pressure.

°°) Force at which front of tractor is calculated to lift with maximum allowable front ballast is in excess of the measured values.

LINKAGE GEOMETRY WHEN CONNECTED TO THE STANDARD FRAME

	Maximum mechanical advantage	Minimum mechanical advantage
Projected length in side view :		
Lower links	953 mm	953 mm
Lift arms	330 mm	330 mm
Lift rods	640 mm	540 mm
Top links	682 mm	682 mm
Distance of lift rod connection point from pivot point of lower link	500 mm	460 mm
The following dimensions are given relative to rear axle centre line 760 mm above ground		
Lower link pivot point	130 mm behind, 255 mm below	130 mm behind, 255 mm below
Top link pivot point	385 mm behind, 210 mm above	385 mm behind, 210 mm above
Lift arm pivot point	170 mm behind, 285 mm above	170 mm behind, 285 mm above
Maximum and minimum height of lower link hitch points	25 mm above, 730 mm below	215 mm above, 541 mm below
Height of lower link hitch points when locked in transport position	No definite transport position	No definite transport position

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ADDITIONAL TEST

Out of the O.E.C.D. CODE under the responsability of the "Station de Génie Rural de l'Etat".

NOISE AT THE DRIVER'S EAR LEVEL

Date of test : 30.11.78
Test track : concrete
Type of sound level meter : BRUEL & KJAER, type 2203
Type of frequency analyser : BRUEL & KJAER, type 1613

The tractor was fitted with a safety cab

Results of test :

Octave analysis in the 3B gear of which the travelling speed is nearest to 7,5 km/h reported in the diagram of the noise rating curves.

Gear	Travelling speed	Sound level	
	km/h	dB(A)	Noise rating
3 B	7,16	85,5	83

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Area limited by the maximum and minimum values of the octave analysis by all speeds.

