SOUTH AFRICAN SUGARCANE RESEARCH INSTITUTE

MECHANISATION REPORT No. 1 2019

South African Sugar Association
170 Flanders Drive, Mount Edgecombe, KwaZulu-Natal
Private Bag X02, Mount Edgecombe, 4300
Telephone: +27-31-508 7400 Facsimile: +27-31-508 7597
Website: http://www.sugar.org.za

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South African Sugarcane Research Institute is a division of the South African Sugar Association

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MECHANISATION REPORT NO. 1

2019 Update

COSTING MACHINERY SYSTEMS

Graphs which may be used to estimate the total cost of operating individual machines or complete machinery systems have been updated and are attached. Costs include those for interest on investment (8,25%), depreciation, licences and insurance, fuel (R13,19/litre - includes a rebate of R0/litre), repairs and maintenance, tyres and the operator. These graphs cover:

Agricultural tractors	:	Figure 1
Haulage tractors	:	Figure 2
Trailers	:	Figure 3
Loaders	:	Figure 4
Implements	:	Figure 5
Attachments	:	Figure 6
Road haulage vehicles - trucks	:	Figure 7
Transloading cranes	:	Figure 8

To use these graphs, a grower must have a reasonably accurate estimate of the number of hours a machine will operate per year. The total distance travelled by trucks (Figure 7) and the total number of tons handled per year by transloading cranes (Figure 8), must also be known.

The cost per hour (or kilometre) is then read off the relevant graph, against the annual use. Once the cost per operating hour is known, the cost per ton or hectare can be calculated.

In the case of a loader or cutter, the hourly cost of the attachment (Figure 6) must be added to that of the tractor (Figure 1) acting as prime mover.

The use of the graphs is illustrated by the following examples:

EXAMPLE 1:

A total area of 20 ha must be disc-harrowed three times per year. The price of the disc harrow chosen for this task is R55000 and a 60 kW FWA tractor is used to pull it. The effective width of cut is 2,0 m.

Rate of work

From Table 1, a speed of 6 km/h and a field efficiency of 80% are chosen, and field conditions are assumed to be reasonably good.

Total distance travelled/ha = $\frac{10\,000}{2,0}$ (1 ha = 10 000 m^2)

= 5 000 m/ha

Time required/ha = $\frac{\text{distance}}{\text{speed}} = \frac{5\,000}{6 \times 1\,000}$

= 0,83 h/ha

Rate of work = $\frac{\text{time required/ha}}{\text{field efficiency}} = \frac{0,83}{0,80}$

= 1,04 h/ha

Annual utilisation

20 ha are worked three times, ie a total of 20 x 3 = 60 ha to be disced. Rate of work is 1,04 h/ha, so the annual utilisation of the disc harrow will be 1,04 x 60 = 62,4 hours.

It is assumed that the tractor is used for various other tasks, adding up to an annual utilisation of the tractor of 1 000 hours.

Cost of operation

For the disc harrow, read off from Figure 5 from the graph for R55000, and at 62,4 hours per year, that the cost is R115,55/h. For the tractor, from Figure 1, at 1 000 h/year the cost for a FWA 60 kW tractor is R261,74/h. Total cost is thus R115,55/h + R261,74/h = R377,29/h.

To disc one hectare once will thus cost R377,29/h x 1,04 (rate of work) = R392,38/ha.

Note that if the disc harrow could be better utilised, say for 40 ha disced three times per year (i.e. 125 h/year), its cost would drop to R63,97/h, and the total cost per hectare would be reduced to R338,74/ha.

Any other field operation can be costed in the same way. Prices must be for current replacement value. Width of cut or swath covered per pass is important, particularly in fertilising or crop spraying operations, and must be determined as accurately as possible.

EXAMPLE 2:

15 000 tons of cane are to be transported per year from the field to a loading zone. Average one-way distance is 1,5 km. Using a 55 kW 2WD tractor and a single stack self-loading trailer working 200 days, 8 hours per day, calculate the number of tractor-trailer units required, and the cost per ton. Average stack size is 5 tons and one conductor is used with the self-loading trailer.

Number of transport units required

Infield tractor-trailer speed is about 15 km/h (Table 2), and to travel to and back from the field will require $\frac{2 \times 1,5 \times 60}{15}$ = 12 minutes.

To load one stack of cane onto a self-loading trailer takes about 5 minutes (Table 2), unloading requires another 5 minutes and allowance must be made for downtime, say another 2 minutes. The total cycle time for this operation should thus be: 12 + 5 + 5 + 2 = 24 minutes. There are 480 minutes in an eight-hour day, so $\frac{480}{24}$ = 20 cycles are possible.

The crop is 15 000 tons per year, or 75 tons per day are to be moved. Payload is 5 tons, so 15 cycles will be sufficient. One tractor-trailer unit can do 20, so it will be adequate.

Annual utilisation

The number of operating hours required per year for this operation must be calculated. Each cycle takes 24 minutes, but the tractor and trailer is not operating for all of these 24 minutes. In fact, only the travelling and the loading time should be considered, i.e. 12 + 5 = 17 minutes per cycle.

This figure is usually increased by 10% to allow for contingencies and the total annual operating hours are then calculated as: 17 minutes operating cycle + 10% = 19 minutes; therefore time for 15 cycles/day for 200 days = $\frac{19 \times 15 \times 200}{60}$ = 950 hours.

Cost of haulage

From Figure 1, a 55 kW 2WD tractor working 950 hours per year will cost R208,95/h. From Figure 3, a single stack, self-loading trailer working 950 hours per year will cost R77,83/h. Total cost is thus R286,78/h, or R286,78/h x 950 = R272441 per year to haul 15 000 tons, i.e. R18,16/ton.

Any other loading or haulage operation, using any machine or series of machines, can be costed similarly. Performance standards must be realistic and if a grower does not have his own standards, those listed in Table 2 could be used as a general guide.

EXAMPLE 3:

15 000 tons of cane are to be loaded from small hand-made bundles with a hi-capacity Bell 125 (3 cylinder) loader into a 6 ton basket trailer for a 1,5 km haul to a loading zone. The trailer is pulled by a 55 kW 2WD tractor. Calculate the number of units required and the cost per ton for this operation.

Loading

Assume overall annual loading rate is 22 t/h (Table 2)

Annual hours $\frac{15\,000}{22}$ = 682

Cost per hour (Fig 4) = R316,71

Total annual cost = R316,71 x 682 = R215996

Cost per ton = $\frac{R215996}{15\,000}$ = R14,40/ton

Haulage

Cycle time:

travel @ 15 km/h : $\frac{2 \times 1,5 \times 60}{15}$ = 12

loading 6 tons @ 30 t/h : $\frac{6 \times 60}{30}$ = 12 (Instantaneous Rate – Table 2)

unloading : 5

downtime : 3

total : 32 min

Must do $\frac{15\,000}{200}$ = 75 tons per day

Payload = 6 tons

No of trips required = $\frac{75}{6}$ = 12,5 (say 13)

No of trips possible = $\frac{480}{32}$ = 15

So one tractor-trailer unit will be sufficient but it will work a full day. The loader will only operate for $\frac{12 \times 13}{60}$ = 2,6 h/day, but will be required in the field for the full day.

Operating hours per year

12 + 12 = 24 minutes per cycle

plus 10% = 26,40 min

Time for 13 cycles/day for 200 days = $\frac{26,40 \times 13 \times 200}{60}$ = 1 144 h

One can argue that while being loaded, the tractor and trailer only operates intermittently, say 50%

of the time, and a more acceptable operating time per cycle would be:

$12 + \frac{12}{2} = 12 + 6$ = 18 minutes per cycle

plus 10% = 19,80 min

Time for 13 cycles/day for 200 days = $\frac{19{,}80 \times 13 \times 200}{60} = 858$ h

Tractor cost (Fig 1) = R 217,27/h

Trailer cost (Fig 3) = R 79,85/h

Total cost = R297,12/h

Total annual cost = R297,12x 858 = R 254929 to haul 15 000 tons

Cost per ton = R 17,00/ton

Total system cost = loading = R 14,40/ton
+hauling = +R 17,00/ton
= R 31,40/ton

This can be compared with Example 2, where the cost for a similar situation, using self-loading trailers was found to be R18,16/ton, excluding the cost of manual stacking.

Haulage costs could be reduced if a 35 kW 2WD tractor is used. Cost per ton for such a tractor and the 6-ton basket trailer would be R14,73/ton. (Tractor cost = R177,63/h)

Alternative
Use two 55 kW 2WD tractor-trailer units.

Operating hours per year
Each tractor-trailer must now complete 6,5 cycles per day, each hauling half the allocation, i.e. 7 500 tons per year.

Operating time (/year) = $\frac{19{,}80 \times 6{,}5 \times 200}{60}$ = 429 h

Tractor cost (Fig 1) = R313,35/h

Trailer cost (Fig 3) = R 150,71/h
= R464,06/h

Total annual cost = R464,06x429 = R199082 to haul 7 500 tons

Cost per ton = R26,54/ton

Total system cost = loading = R 14,40/ton
+hauling = +R26,54/ton
R40,94/ton

The daily task will, however, be done in 4 hours.

EXAMPLE 4:

15 000 tons of cane per year are to be transported 15 km from a loading zone to a mill. Calculate the cost for transloading by Tractor trailed crane and for haulage. Bundles average 4 tons each.

Transloading

Five minutes are required to unload a bundle from infield trailers and another 5 minutes (Table 2) to load it later onto a truck.

Annual operating hours = $\frac{15\,000}{4}$ x 10 min

= 3 750 bundles x 10 min each

= 625 h

Cost per operating hour (Fig 8, graph 1) = R453,31/h

Total annual cost = R453,31 x 625 = R283319

Cost per ton = $\frac{R283319}{15\,000}$ = R18,89/ton

Haulage

An 8-ton truck can carry two bundles at a time. If bundles average 4 tons each, 3 750 bundles must be hauled per year, i.e. 1 875 trips.

Each trip is 15 x 2 = 30 km

Total annual distance = 30 x 1 875 = 56 250 km

Cost per km (Fig 7) = R9,70/km

Cost per year = R9,70 x 56 250 = R545625

Cost per ton = R36,38/ton

A 14-ton truck can carry three bundles. Annual trips will thus amount to 1 250, i.e. 37 500 km will be travelled.

Cost per km = R15,56/km

Cost per year = R15,56 x 37 500 = R 583500

Cost per ton = R38,90/ton

Table 1: Field efficiencies and operating speeds

IMPLEMENT	SPEED (km/h)	EFFICIENCY (%)
Subsoiler	3,0- 8,0	70-90
Plough, m/b, disc or chisel	3,0- 8,0	70-90
Powered rotary tiller	3,0- 8,0	70-90
Harrow, off-set	4,0-10,0	70-90
Harrow, spike-tooth	4,0-10,0	70-90
Rotary cultivator	6,0-12,0	70-90
Cultivator – general	4,0-8,0	70-90
Cultivator - row crop	4,0- 8,0	70-90
Ridger	3,0- 8,0	60-80
Cane Planter	3,0- 8,0	40-50
Fertiliser spreader	4,0- 8,0	60-75
Long box-type spreader	4,0 - 8,0	40-55
Herbicide boom sprayer	4,0- 8,0	40-60
Mower - cutter bar	8,0-11,0	75-85
Mower – rotary	4,0-10,0	75-85
Rake	4,0- 8,0	70-85
Cutters - whole-stick	3,0-10,0	40-75
Harvester – chopper	3,0-10,0	40-75

Table 2: Performance standards for cane handling operations

OPERATION		STANDARD
Cane cutters/harvesters:		
Front mounted cutter		15-30 t/h
Tractor mounted bundle cane harvester		15-40 t/h
Chopper harvester		20-80 t/h
Loaders (infield):		
non-slewing, tractor mounted		8-15 t/h
slewing, tractor-mounted, loading from windrows		20-60 t/h
non-slewing, self-propelled	a) loading from windrows	20-25 t/h
	b) loading from small bundles	20-25 t/h
	instantaneous rate	30 t/h
	c) carrying cane to parked trailer	10-25 t/h
	instantaneous rate	22 t/h
Transloaders (load and unload):		
	crane – self-propelled or Scotch type	5 min/bundle
	four-pole gantry	10 min/bundle
Self-loading trailers	loading from side or rear	5 min/bundle
Tractor speed:	infield	10-20 km/h
	on road	25 km/h
Lorry speeds:	short hauls	35 km/h
	long hauls	45 km/h

FIGURE 1 AGRICULTURAL TRACTORS

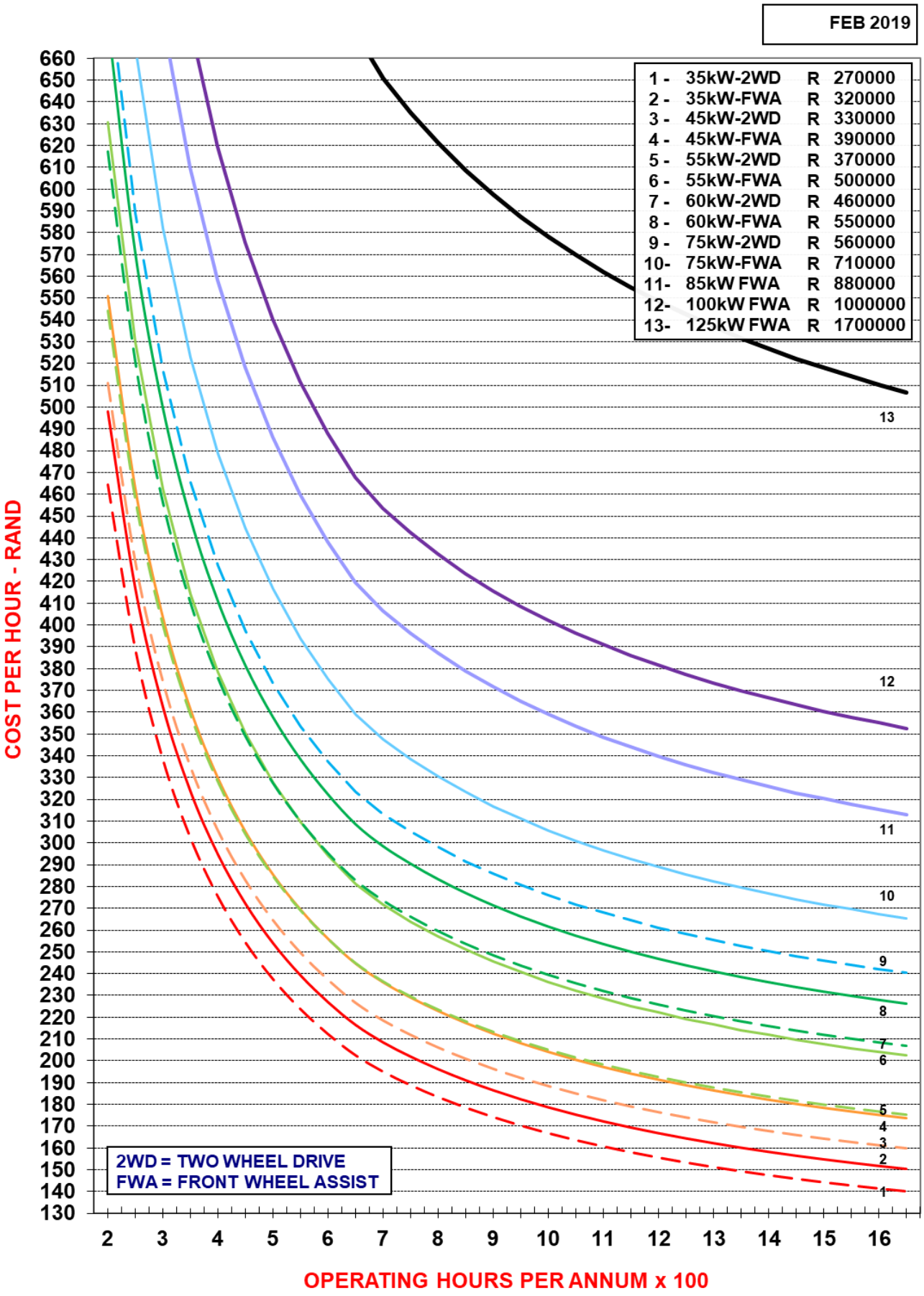

FIGURE 2 HAULAGE TRACTORS

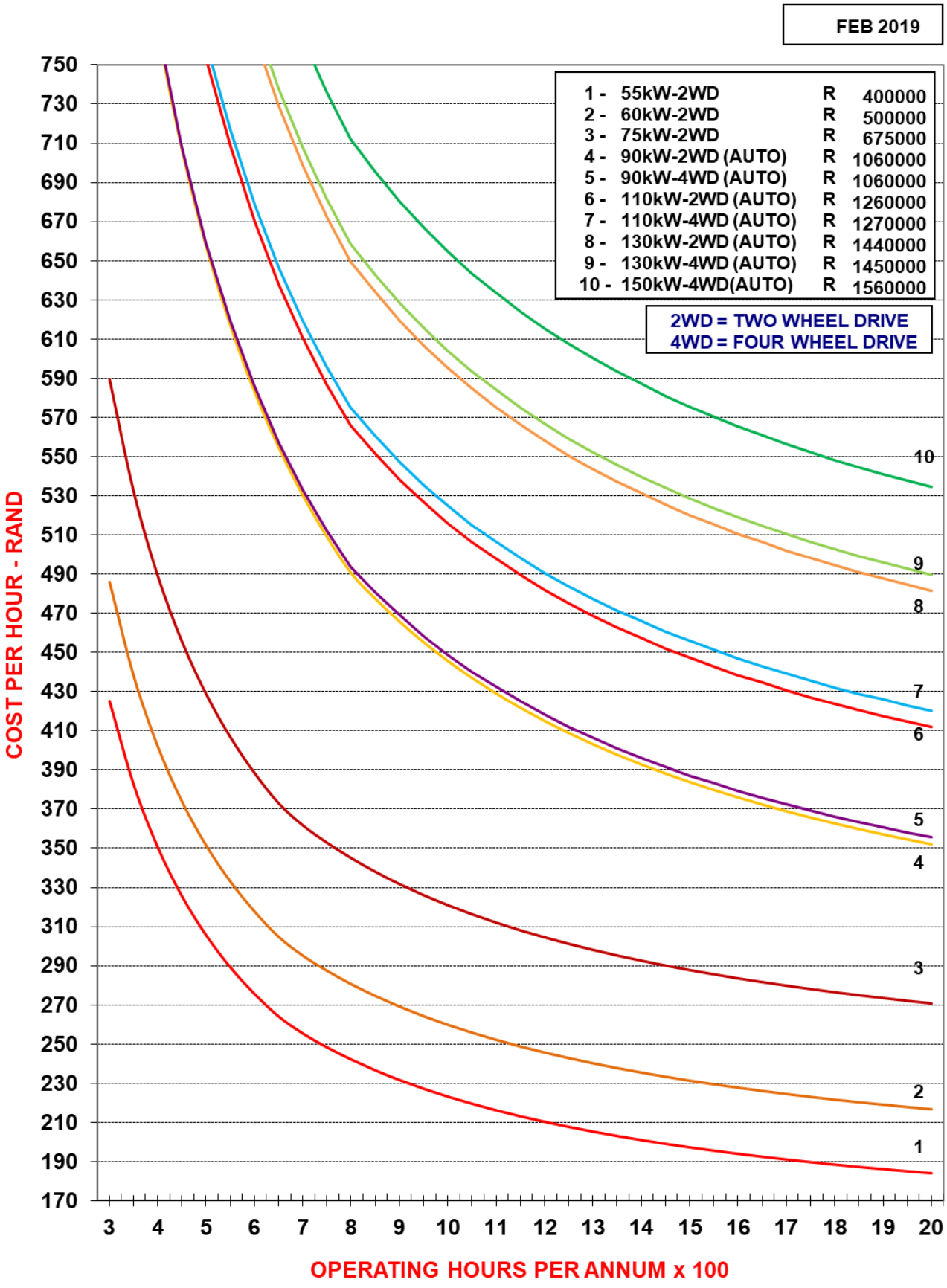

FIGURE 3 TRAILERS

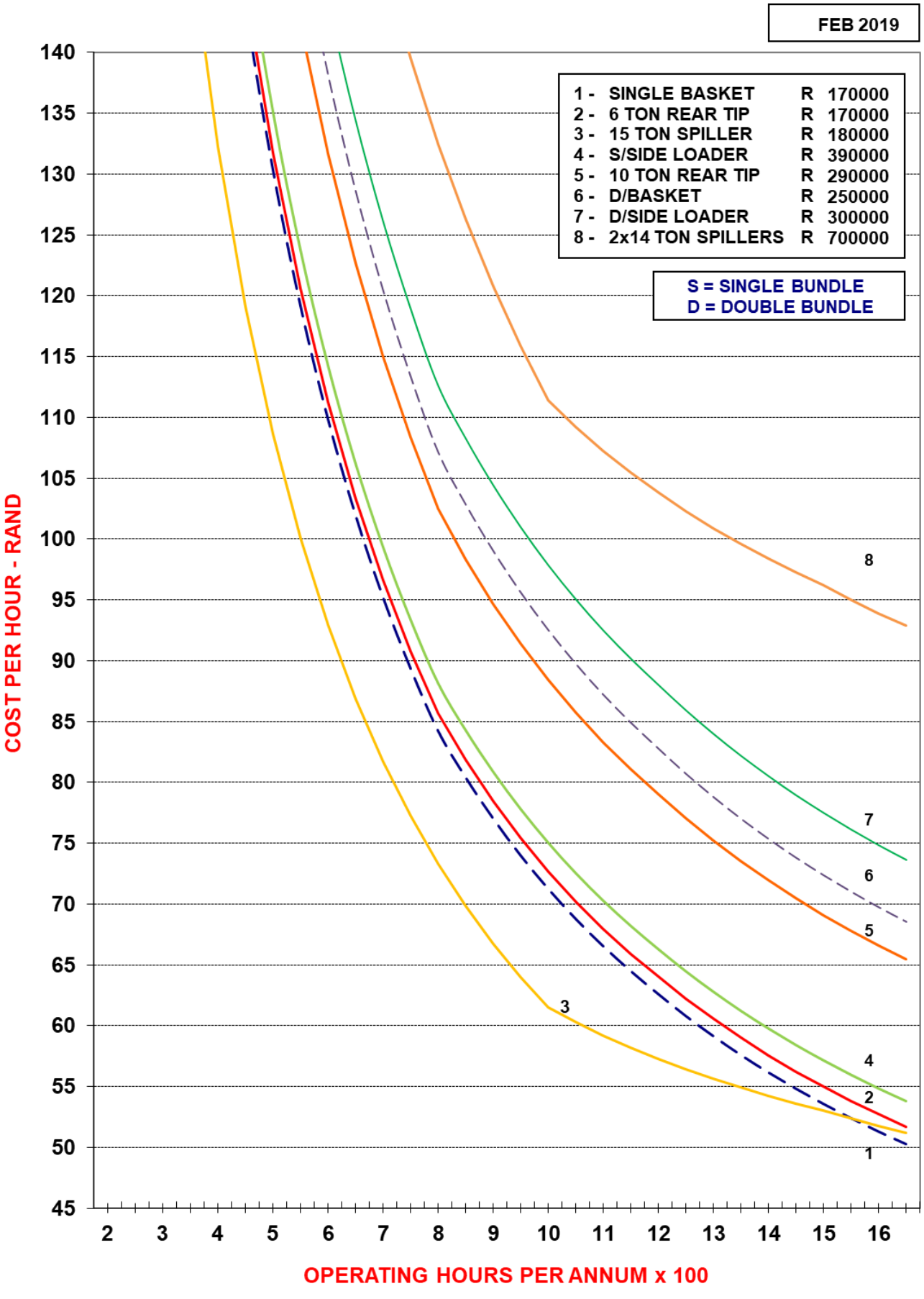

FIGURE 4 LOADERS

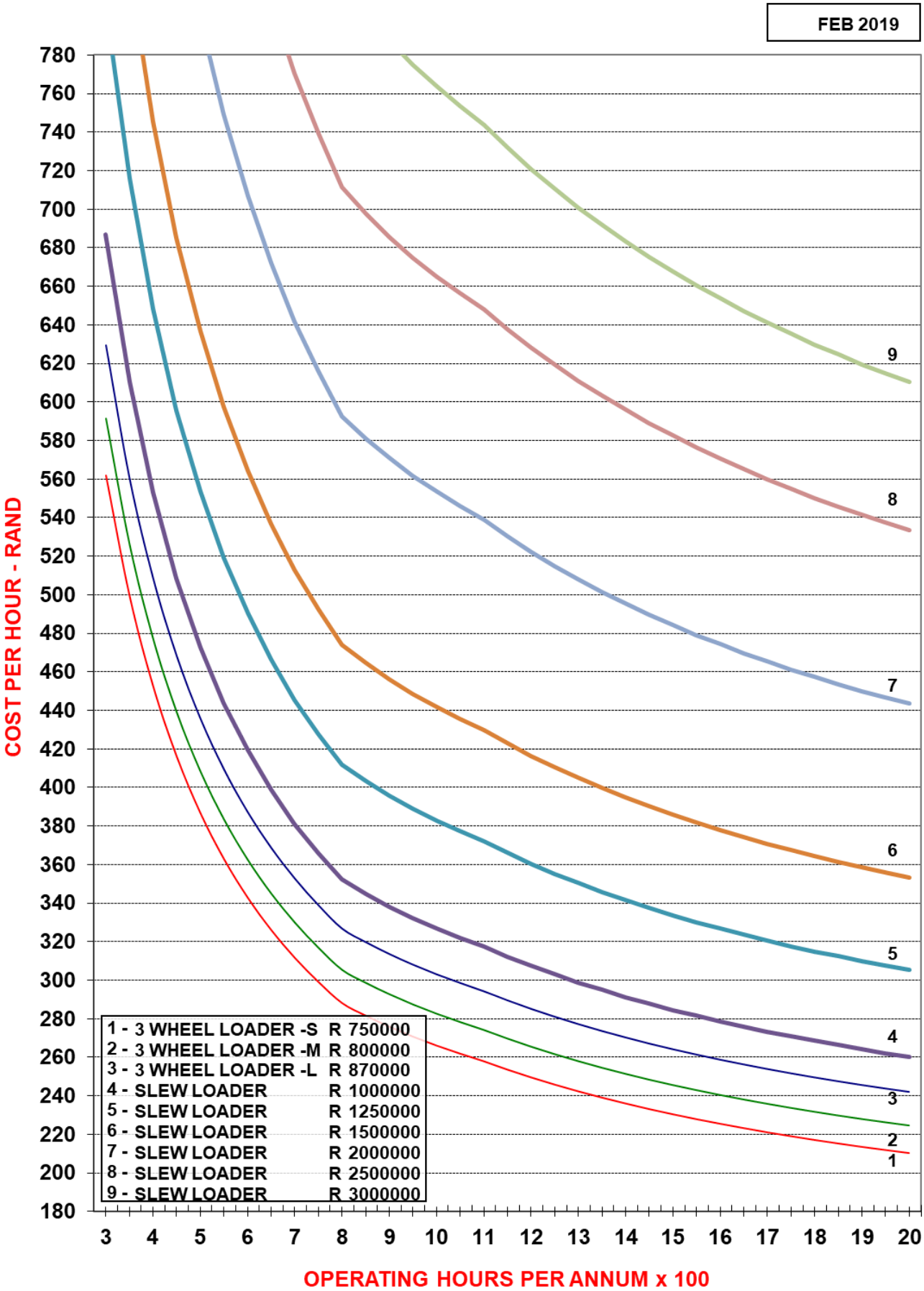

FIGURE 5 IMPLEMENTS

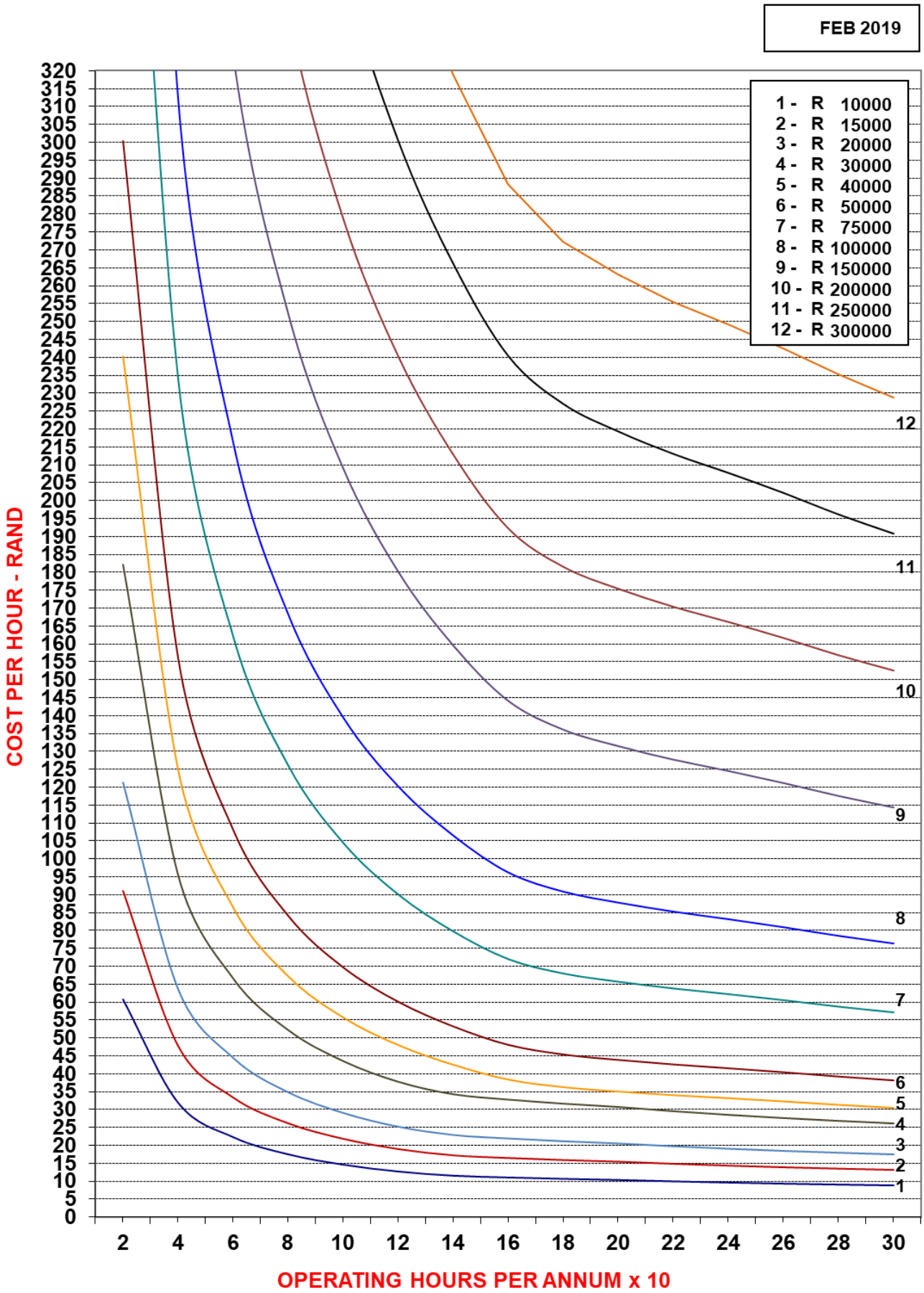

FIGURE 6 ATTACHMENTS

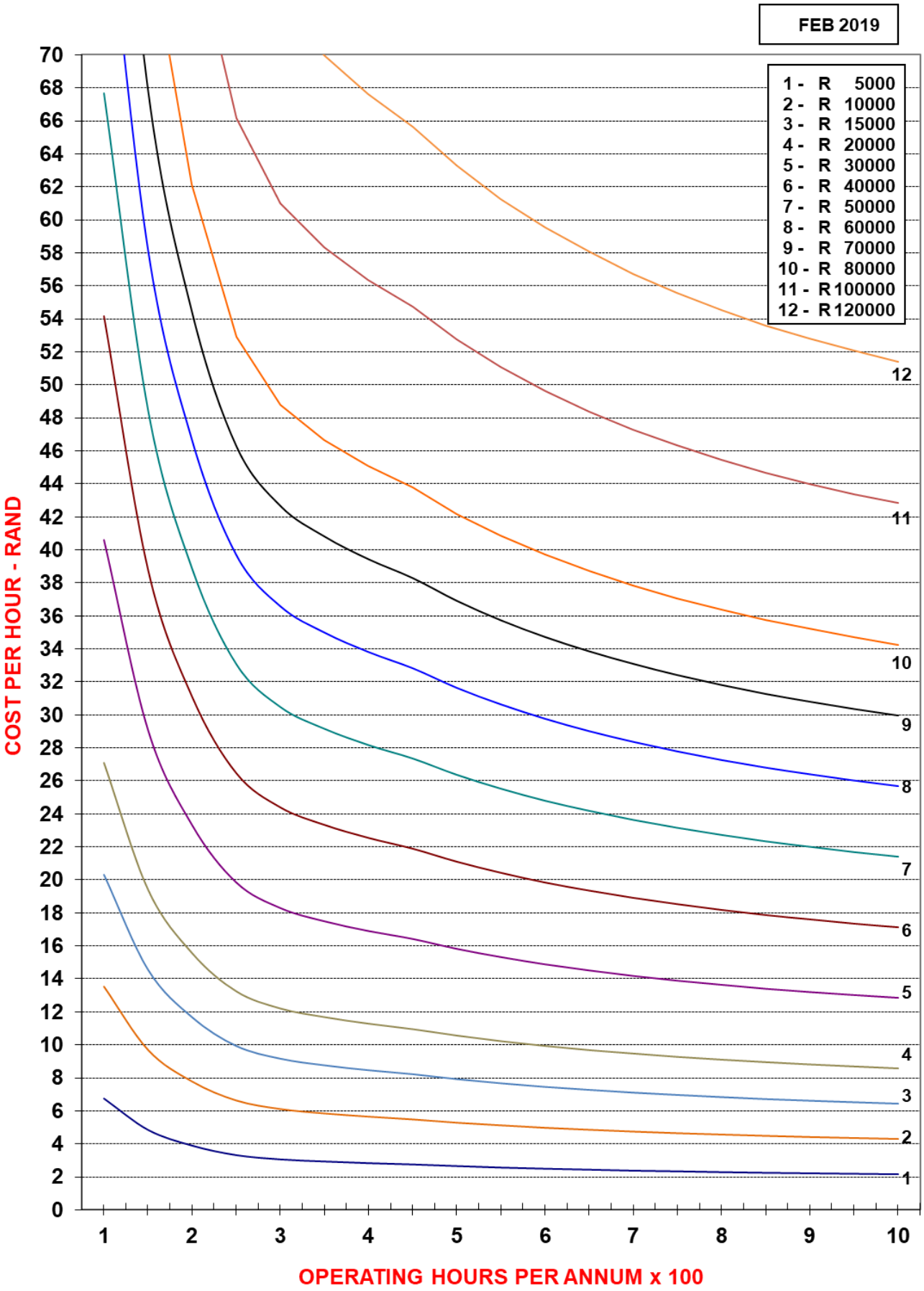

FIGURE 7 ROAD HAULAGE VEHICLES - TRUCKS

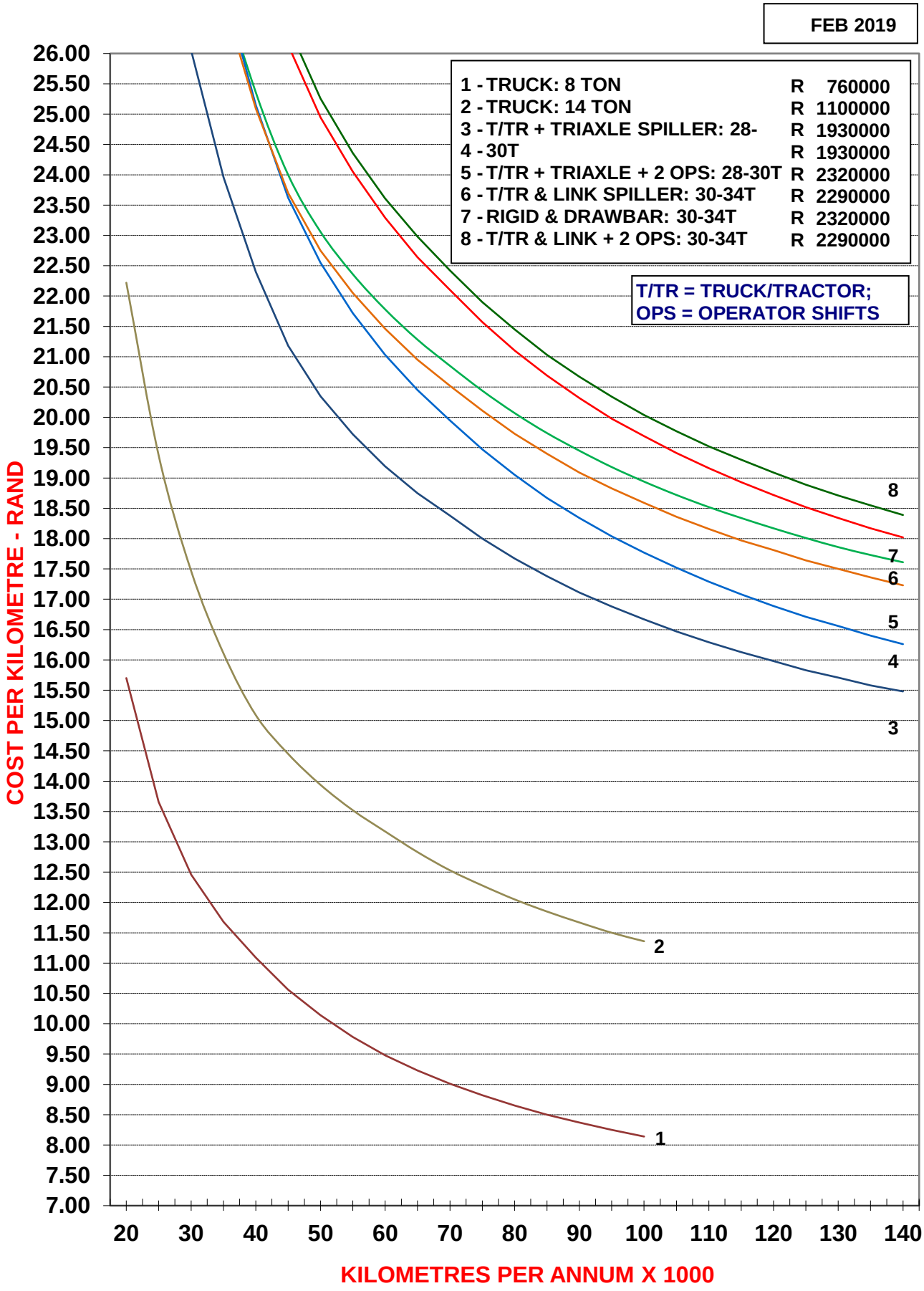

FIGURE 8 TRANSLOADING CRANES

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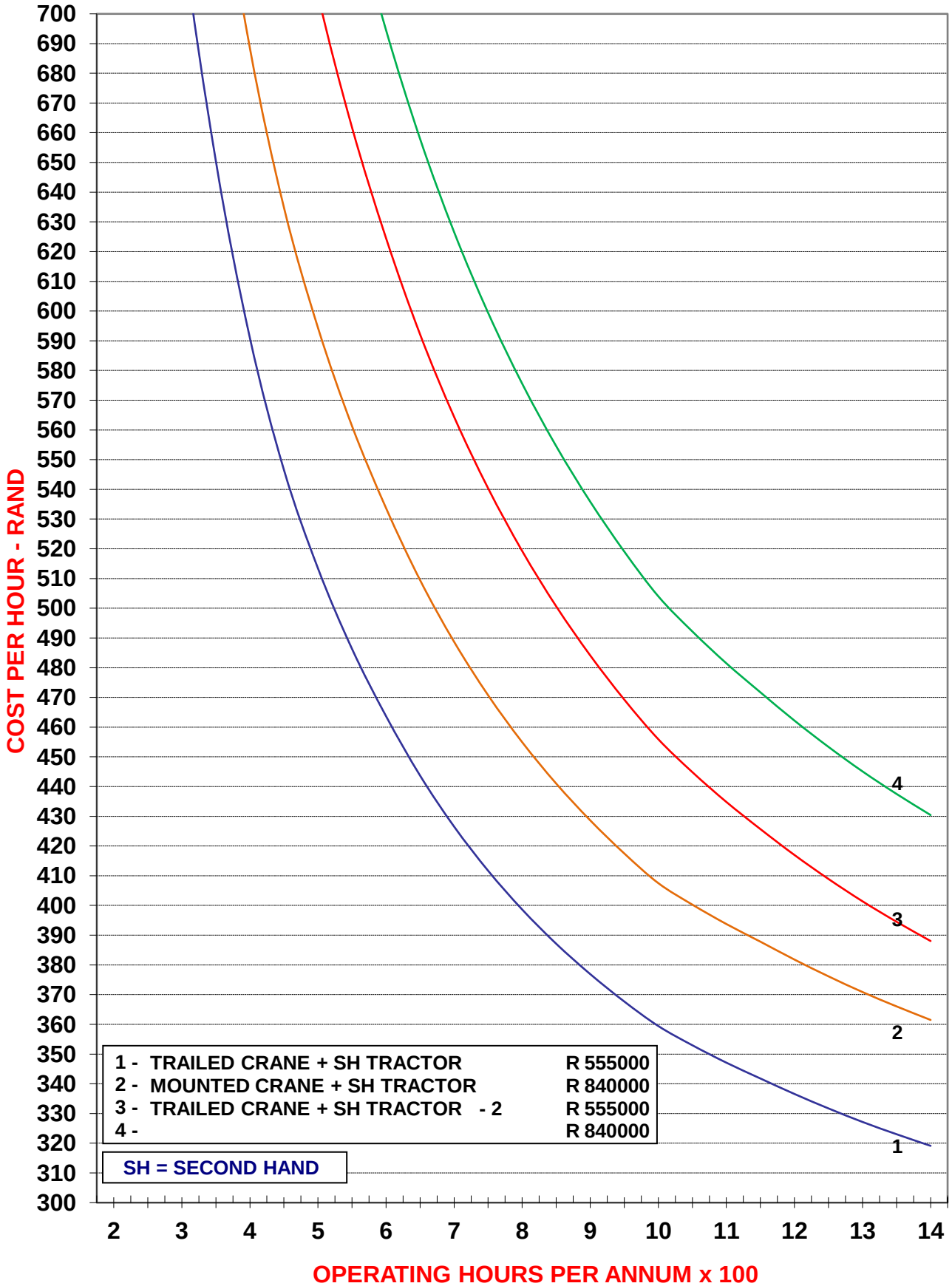

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- Matriarch Equipment
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