

**FLANNERY®**

# Fuel Saver Handbook



**People | Safety | Innovation | Sustainability | Value**

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## **One of the largest contributors to on-site emissions comes from the machines we provide and that you operate.**

Whilst the technology available to us continues to improve at a rapid rate, the way in which we use our machines still plays an integral role in our overall fuel consumption and the ultimate impact we have on the environment.

Idling alone makes up a significant proportion of our typical working day. Whilst some idling can be attributed to the nature of the tasks we perform, excessive idling consumes tens of thousands of litres of fuel unnecessarily every month. Everyone from the management teams to you - our operators - have a part to play in controlling this impact.

Did you know that from April 2022 red diesel will not be available to the construction and infrastructure sector? That means an increase from 11.14p to 57.95p per litre.

Have you heard about net-carbon zero? The UK is focused on delivering on this ambition 2050. Most of our tier one clients have made their own commitments to be meet their own net-carbon zero targets.

What do you want your legacy to be? As a plant operator you are involved in the creation of buildings and infrastructure that will last for many years to come. It is our responsibility to minimise the negative effects of our work, both on the environment and the communities that surround the projects we support.

This guide focuses on the best practise and behaviour to reduce fuel usage and maximise fuel efficiency and explains how you can be a little but greener in how you operate your machine. Please be proactive in your approach to using this guide and always reference your machines operator handbook if in any doubt.

Please note that fuel statistics quoted here may vary depending on site conditions, machine make, and model and the task being carried out.

# Hydraulic Excavator

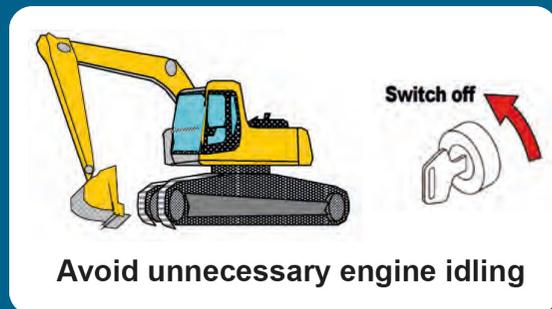


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# 1. Idling – Hydraulic Excavator

## Advice

- Stop the engine as much as possible.
- Do not leave the engine idling during waiting times or breaks.



## Key point

While it is necessary to keep an engine idling for 2-3 minutes after start up and before shutting down, unnecessary engine idling consumes fuel for no reason.

## Test data

20-ton class Hydraulic Excavator

Annual flue savings

When idling	0.76 L / H	➔	228 L / Year
When idling in auto deceleration mode	3.30 L / H		990 L / Year

Conditions: 1 hour engine idling reduction per day and 25 work days per month.  
This fuel consumption amount will further increase if a machine is idling in the auto deceleration \* mode i.e., it consumes approx 3.3 litres an hour.

## Remarks

\* Auto Decel Idling:

Auto deceleration is a function built into many hydraulic excavators. It serves to automatically reduce the engine revolution to the medium speed when the control lever is left in the neutral position for 4 seconds such as when the machine is waiting for a ADT, thereby lowering fuel consumption and noise.

## 2. Digging – Hydraulic Excavator

### Advice

- Avoid relieving hydraulic pressure as much as possible. Do not over dig.
- Aim at smooth digging by lessening the load.



### Key point

When loading, ensure you are working within the machines capabilities to avoid hydraulic stalling.

If the machine is stalled hydraulically it will remain stationary BUT will still be using fuel.

### Test data

20-ton class Hydraulic Excavator

Annual fuel savings

When hydraulic pressure is relived

28 L /H



840 L / Year

Conditions: 6 min. Hydraulic pressure relief reduction per day and 25 work days per month.

### 3. Digging & Loading – Hydraulic Excavator

#### Advice

- Reduce engine speed.
- Use Eco Mode\*.



#### Key point

In the same operation, lower engine speed, requires less consumption. Lower engine speed reduces productivity as well, but compensates with improved fuel efficiency.

Use the machine in the correct mode in accordance with the handbook. i.e trimming/ finishing eco-mode, lifting power mode, bulk excavations normal mode. Use eco mode where possible unless the task required a different mode

#### Test data

20-ton class Hydraulic Excavator (Conditions)

1. Loading an ADT parked on the same ground level (height)
2. Digging downward
3. Loading an ADT using 90° swing angles
4. Sand and earth to be dug out

Items	Mode	Throttle	Index	Effect
Cycle Time	A	Full	100%	-
		10% less	109%	+9%
	E*	Full	111%	+11%
Fuel Consumption (L / H)	A	Full	100%	-
		10% less	88%	-12%
	E*	Full	77%	-23%
Production (Ton / H)	A	Full	100%	-
		10% less	93%	-7%
	E*	Full	88%	-12%
Fuel Efficiency (Ton / L)	A	Full	100%	-
		10% less	104%	+4%
	E*	Full	114%	+14%

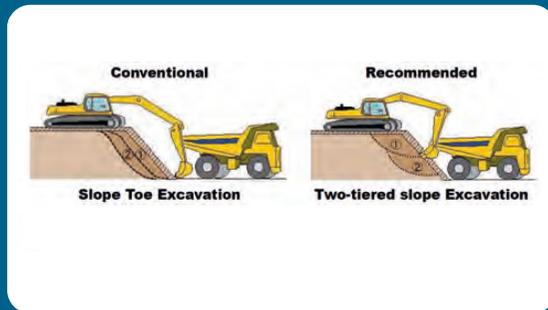
Fuel efficiency varies depending on the kind of sand and earth to be dug out.

#### Remarks

\* E Mode (Eco Mode): This is a function built into many 20-ton class hydraulic excavators. In this mode, the engine power is used at approx. 85% of the full throttle. (It is effective for reducing fuel costs and noise.)

## Advice

- Raise excavation position.
- Conduct two-tiered excavation.



## Key point

The bench height should be the same height or slightly higher than the ADT body. Excavating the upper side of the slope first and then working on the exposed lower portion shortens cycle time compared with slope toe excavation.

## Test data

20-ton class Hydraulic Excavator (Conditions)

1. Loading an ADT parked on a lower ground level
2. Digging downward
3. Loading an ADT using 90° swing angles
4. Sand and earth to be dug out

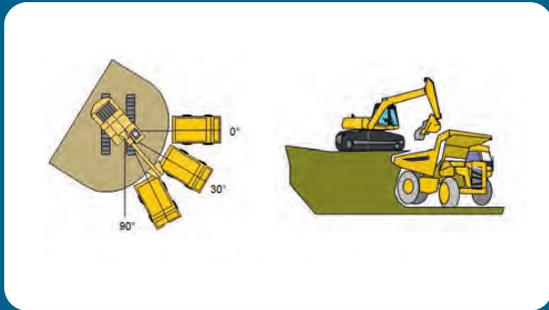
Items	Operation Type	Index	Effect
Cycle Time	Slope Toe	100%	-
	Two-tiered slope	88%	-12%
Fuel Consumption (L / H)	Slope Toe	100%	-
	Two-tiered slope	98%	-2%
Production (Ton / H)	Slope Toe	100%	-
	Two-tiered slope	106%	+6%
Fuel Efficiency (Ton / L)	Slope Toe	100%	-
	Two-tiered slope	108%	+8%

Fuel efficiency varies depending on the kind of sand and earth to be dug out.

# 4. Loading – Hydraulic Excavator

## Advice

- Reduce swing angle.
- Position the excavator closer to the ADT.

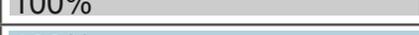


## Key point

When loading ADTs, reducing the swing angle can accelerate the cycle time, boost hourly productivity and raise fuel efficiency.

## Test data

20-ton class Hydraulic Excavator

Items	Swing Angle	Index	Effect
Cycle Time	90°	100% 	-
	30°	96% 	-4%
Fuel Consumption (L / H)	90°	100% 	-
	30°	101% 	+1%
Production (Ton / H)	90°	100% 	-
	30°	104% 	+4%
Fuel Efficiency (Ton / L)	90°	100% 	-
	30°	103% 	+3%

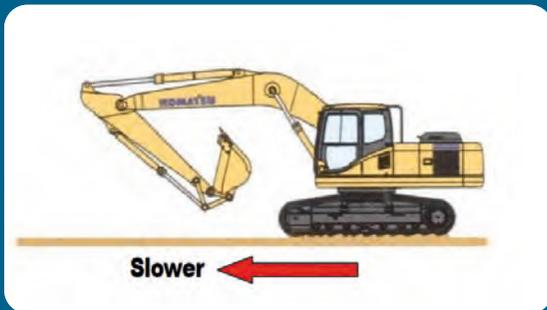
Watch the case study on the Flannery Komatsu Hybrid excavator by scanning this QR code.



## 5. Travelling – Hydraulic Excavator

### Advice

- Travel at slower speeds.



### Key point

Higher travel speeds mean higher engine revolutions, expending more fuel and increases track wear and additional stress on the machine and engine. select the shortest route and it may be more beneficial to use a low loader on long distances rather than track the machine.

Conversely, lowering the engine speed improves travelling fuel efficiency.



# Wheel Loader

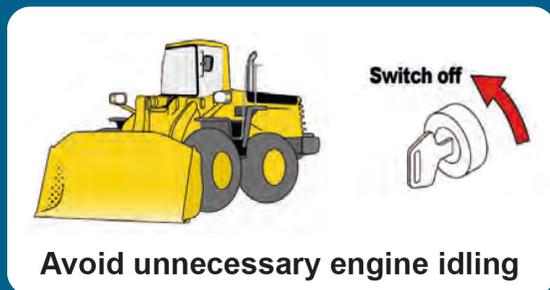


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# 1. Idling – Wheel Loader

## Advice

- Stop the engine as much as possible
- Do not leave the engine idling during waiting times or breaks



## Key point

While it is necessary to keep an engine idling for 2-3 minutes after start up and before shutting down, unnecessary engine idling consumes fuel for no reason. Unnecessary engine idling consumes fuel for no reason.

## Test data

3.4m<sup>3</sup> bucket size class Wheel Loader

Annual fuel savings

Idling fuel consumption	4.20 L /H	➔	1260 L / Year
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Conditions: 1 hour engine idling reduction per day and 25 work days per month.

## 2. Digging – Wheel Loader

### Advice

- Avoid relieving hydraulic pressure and torque converter stall.



### Key point

When digging out sand and earth imposes too big of a load, the work equipment will not move even though the control lever is kept engaged, as the torque converter stalls and hydraulic pressure is relieved.

Work within the machines capability, if you attempt to dig out too large a load the machine will stall and will not move while still consuming fuel.

### Test data

3.4m<sup>3</sup> bucket size class Wheel Loader

Annual fuel savings

Avoid machine overloading that leads to stalling

43 L /H

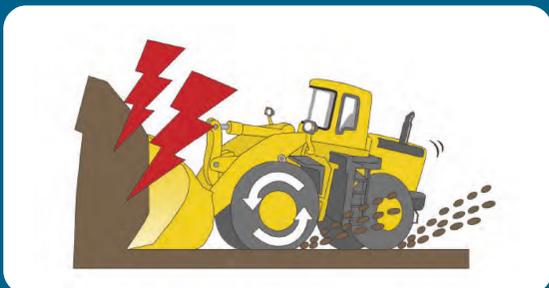


6450 L / Year

Conditions: 30 minutes stalling reduction per day in a 25 work day month.

### Advice

- Avoid tyre slippage.



### Key point

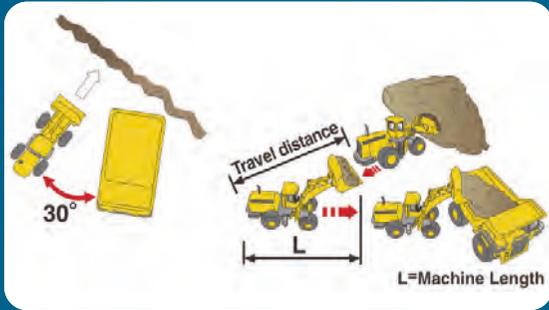
The tyres of a wheel loader tend to slip when it grinds to a halt while digging and the engine is revved to still move it forward. When the tyres slip, the bucket can no longer dig into sand and earth. Prolonged tyre slippage causes excessive tyre wear and consumes fuel for no reason.

1. If the bucket is pressed hard against the ground during the digging operation, pressure on the front tyres is reduced, making it easier for them to slip. Before digging into sand and earth, hold the bucket slightly off the ground.
2. When the tyres show signs of slipping, raise the bucket slightly which will improve traction and complete filling of the bucket in one fluid motion
3. If the tyres begin to slip, release the accelerator pedal once and step on it again gradually to dig and scoop as explained above.

### 3. Loading – Wheel Loader

#### Advice

- Shorten the loading distance.
- Minimise the loading V-angle.



#### Key point

Optimum: Distance 0.8L

Angle: 30°

#### Test data

Items	Distance	Index	Effect
Cycle Time	0.8L	92%	-8%
	1.0L	100%	-
	1.5L	112%	+12%
Fuel Consumption (L / H)	0.8L	101%	+1%
	1.0L	100%	-
	1.5L	101%	+1%
Production (Ton / H)	0.8L	117%	+17%
	1.0L	100%	-
	1.5L	93%	-7%
Fuel Efficiency (Ton / L)	0.8L	116%	+16%
	1.0L	100%	-
	1.5L	92%	-8%

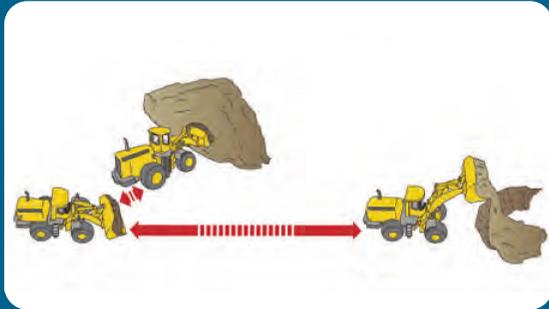
Conditions:

1. 30° V shape loading.
2. Forward and reverse travel distance classified into three stages (L = machine overall length).

## 4. Travelling – Wheel Loader

### Advice

- Travel at slower speeds



### Key point

Higher travel speeds mean higher engine revolutions, expending more fuel. Conversely, lowering the engine speed improves travelling fuel efficiency.

### Test data

Items	Max Travel Speed	Index	Effect
Fuel Consumption (L / H)	21km/h	100% 	-
	17km/h	79% 	-21%
	14km/h	65% 	-35%
Production (Ton / H)	21km/h	100% 	-
	17km/h	91% 	-9%
	14km/h	81% 	-19%
Fuel Efficiency (Ton / L)	21km/h	100% 	-
	17km/h	116% 	+16%
	14km/h	124% 	+24%

Conditions:

1. Load & Carry operation
2. Bucket filled with sand and earth
3. Travel distance of 95m



# Articulated Dump Truck (ADT)



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# 1. Idling – ADT

## Advice

- Stop the engine as much as possible
- Do not leave the engine idling during waiting times or breaks



## Key point

While it is necessary to keep an engine idling for 2-3 minutes after the start up and before shutting down, unnecessary engine idling consumes fuel for no reason.

## Test data

45-ton class ADT

Annual fuel savings

When idling	8 L / H	➔	2400 L / Year
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Conditions: 1 hour engine idling reduction per day and 25 work days per month.

Watch the latest video covering ADT Daily Checks by scanning this QR code.



## 2. Driving – ADT

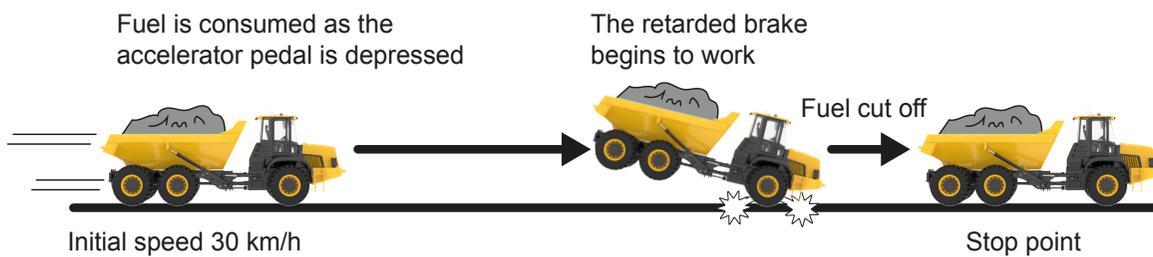
### Advice

- Avoid sharp braking

### Key point

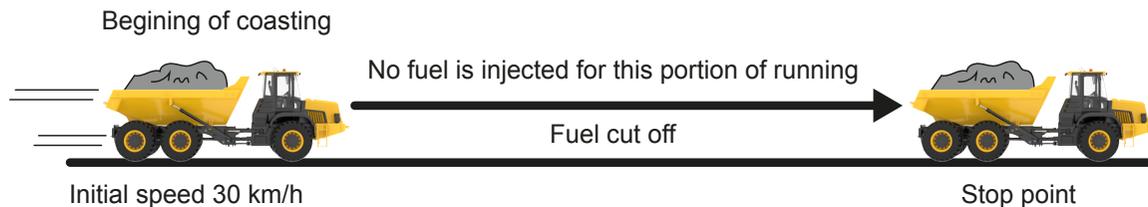
Fuel usage is reduced as the accelerator pedal is released, allowing the machine to coast before applying the brake.

Normal driving Fig. 1



Fuel is consumed until dump truck stops.

Coasting Fig. 2



Driving technique enabling a coasting distance created by the initial speed that can help save fuel.



When a ADT is going down a slope, the driver is required to select an appropriate safety speed, taking into account the initial running speed and slope inclination.

**Never coast on a downslope.**

### Test data

45 ton class ADT with load Condition of hauling road: 100m of start up running and 120m of coasting

Items	Index of Fuel Consumption (L / H)	Effect
Normal Driving (Fig.1)	100%	-
Coasting (Fig.2)	62%	-38%

### 3. Driving – ADT

#### Advice

- Drive at a constant speed
- Do not accelerate and decelerate frequently

#### Key point

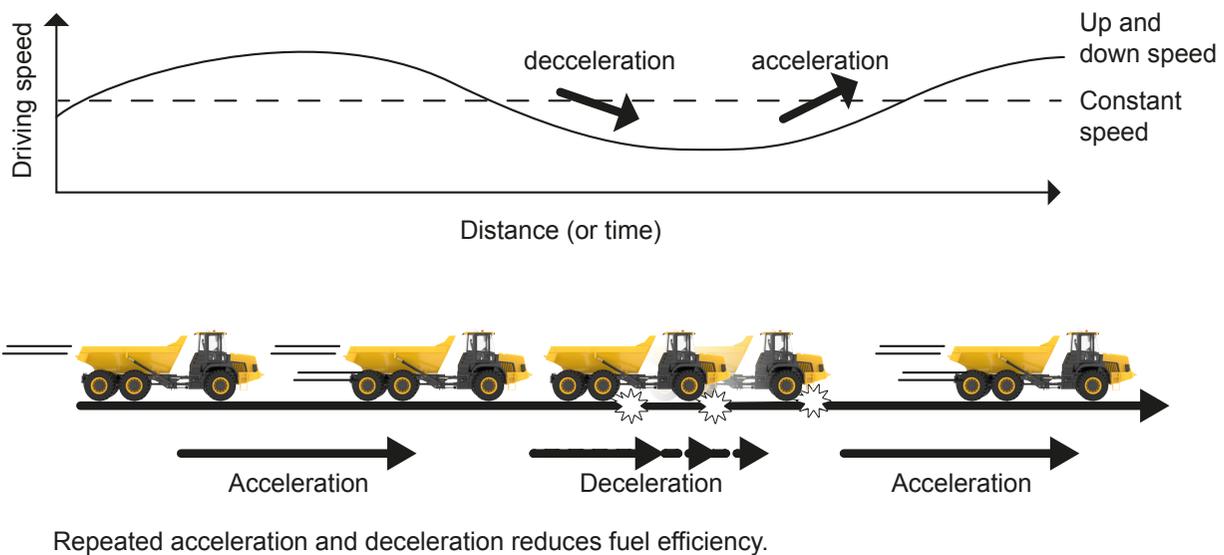
Soft spots in a haul road require increased traction and will increase fuel consumption. Advise your supervisor if there are any soft spots to enable repair.

#### Key point

Driving at constant speed Fig. 1



Frequent acceleration and deceleration Fig. 2



#### Test data

45 ton class ADT with load Condition of hauling road: 100m of start up running and 120m of coasting

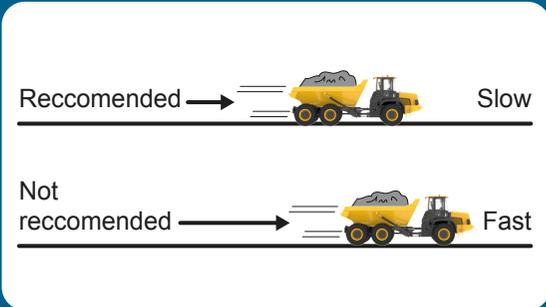
Driving type	Index of Fuel Consumption (L / H)	Effect
Frequent acceleration and deceleration (Fig.1)	100%	-
Constant speed (Fig.2)	87%	-13%

Conditions: Alternating speeding up and slowing down twice between 20 km/h and 30 km/h in a 300m distance.

# 4. Travelling – ADT

## Advice

- Travel at slower speeds



## Key point

Higher travel speeds mean higher engine revolutions, expending more fuel.

Conversely, lowering the engine speed improves travelling fuel efficiency.

Drive in accordance with the site rules and at an appropriate speed for the site conditions.

## Test data

90 ton class ADT with load

Items	Index of Fuel Consumption (L / H)	Effect
Engine at max. revolution	100%	-
Engine at 80% of max. revolution	84%	-45%

## 5. Dumping – ADT

### Advice

- When tipping a load, reduce engine speed
- Make sure to carry out dumping at a lower engine speed.



Carry out dumping at a lower engine speed for less fuel consumption

### Key point

While tipping, the lifting speed of the body changes in proportion to the engine revolution. Therefore the faster the body rises, the more fuel the engine consumes.

In the dumping operation, at 80% of the maximum engine revs, fuel saved can be as much as 45% when compared with dumping at the maximum engine revs.

### Test data

90 ton class ADT with load

Items	Index of Fuel Consumption (L / H)	Effect
Engine at max. revolution	100%	-
Engine at 80% of max. revolution	55%	-45%







# Maintenance for Fuel Savings

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# 1. Basics of Maintenance Work

## Maintenance for Fuel Savings

### Advice

- Ensure that your machine is kept in good condition and follow the daily inspection routine.
- This will ensure that your machine runs in accordance with manufacturers expectations and maximise fuel economy.



Watch the AdBlue refilling video here



### Fuel and AdBlue

AdBlue is an additive used in Tier 4 and above engines that is introduced to exhaust gases to reduce harmful emissions and enhance the environmental performance of Machines. Only use the manufacturers specified coolant and follow the manufacturers guidelines for use.

- Always use designated fuel and AdBlue from a reliable source
- Do not use fuel or AdBlue that contains water or contaminants
- Keep filling equipment, e.g. funnels etc. separate to avoid cross contamination
- Do not allow dirt and dust to get into the fuel or AdBlue
- Fill up the fuel tank after the day's work to minimise condensation
- Drain water from the fuel tank and Adblue tank before starting the engine



### Handling of Oils, Fuel and AdBlue

- Replace oils at a specified interval
- Do not allow dirt and dust to get into oils
- Do not blend oils of different grades and brands
- Fill oils to the specified amount
- **These fluids are potentially harmful and need to be treated with caution. Please refer to COSHH sheet**



### Handling of coolant

- Only use the manufacturers specified coolant and follow the manufacturers guidelines for use



## Handling of Filters

- Air filter efficiency has a huge impact on fuel economy
- Replace filters in line with manufacturer recommendations or as appropriate depending on site conditions (for example dry, dusty sites may increase the frequency of replacement)
- Never reuse filters (cartridge type) even well cleaned
- Only use genuine filters

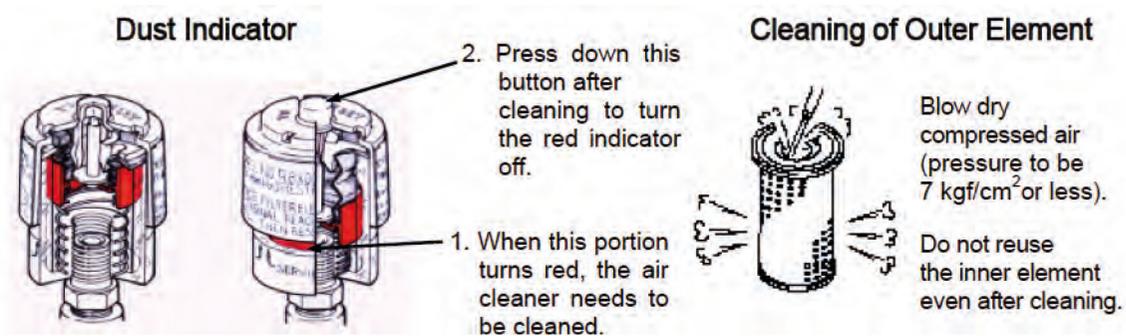
## 2. Engine – Maintenance for Fuel Savings

### 2.1 Air Cleaner

- Clean or replace the outer element to prevent the filter element from clogging when the dust indicator turns red

### Key point

If the air cleaner is clogged the engine will not receive a sufficient air volume, exhaust colour becomes darker and the engine power goes down, and fuel consumption increases larger machines may have an air pre-cleaner bowl. This may need cleaning out daily on dusty sites. This need to be regularly checked.



### 2.2 Diesel Particulate Filters (DPFs)

### Key point

Diesel Particulate Filters are fitted to machines to ensure that harmful emissions are kept to a minimum. It is important that these function at optimal levels. It is essential that the regeneration cycle has run to completion whenever necessary.

### 2.3 Fuel Injection Timing

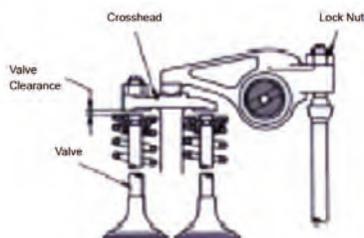
- Check the fuel injection timing.

### Key point

Good fuel combustion does not take place inside the engine unless fuel is supplied at the appropriate timing in tune with the engine speed. When lower engine power or darker exhaust occur, accompanied by more fuel consumption, check whether or not the fuel injection timing is at the proper setting.

## 2.4 Valve Clearance

- Check the valve clearance.



## Key point

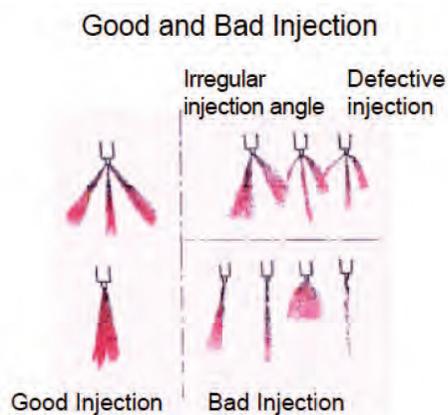
An engine is equipped with valves that move every time the combustion chamber is closed, the air is drawn in or the exhaust gas is blown out.

These valves are activated by a complex mechanical setup. Check the valve clearance every 2000 hours.

1. If a valve clearance is too big: Enough air cannot be taken in, and fuel can not burn completely (darker exhaust and lower engine power).
2. If a valve clearance is too small: The combustion chamber does not close tightly, and fuel can not burn (engine output drastically reduced).

## 2.5 Injection Nozzle

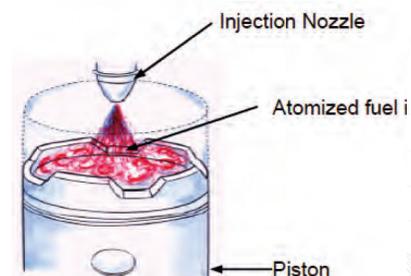
- Do not allow dirt and dust to get into fuel tank while filling, and drain water from the fuel tank regularly.



## Key point

An injection nozzle is used to atomise fuel and inject the atomised fuel into a high temperature, high pressure cylinder. If fuel is not well atomised, good combustion cannot be achieved. This causes engine power to lower and exhaust gas to be darker, this leads to increased fuel consumption.

A major cause of insufficiently atomised fuel is contamination due to water and dust getting into fuel. So in order to prevent engine failure, do not allow dirt and dust to get into the fuel tank while filling and drain water from the fuel tank regularly.



## 3. Fuel System – Maintenance for Fuel Savings

### 3.1 Filter Element

- Replace the fuel filter element periodically

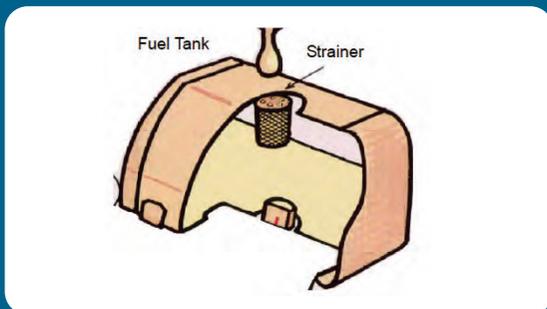


### Key point

A fuel filter element prevents the engine from breaking down and prolongs its service life by providing clean fuel for the engine after removing moisture or dirt and dust contained in fuel. However, major components in the fuel system are lubricated with fuel, and moreover, they are very fine precision parts that are sensitive even to minuscule materials. A trace of them could easily invite seizure, scuffing or rust due to moisture. Therefore, it is necessary to replace the fuel element periodically.

### 3.2 Strainer

- Clean Strainer

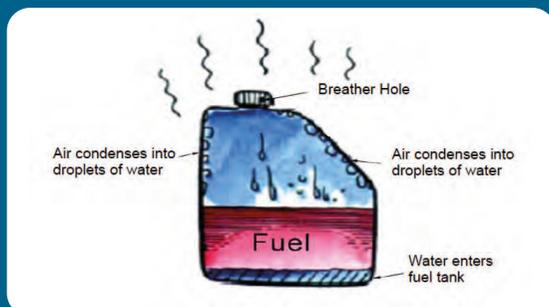


### Key point

A strainer is installed on the fuel filler port. Its function is to remove relatively large sized foreign materials that may enter the fuel tank together with fuel. Do not remove it when pouring fuel. Also, clean it when foreign materials are found upon inspection.

### 3.3 Draining Water

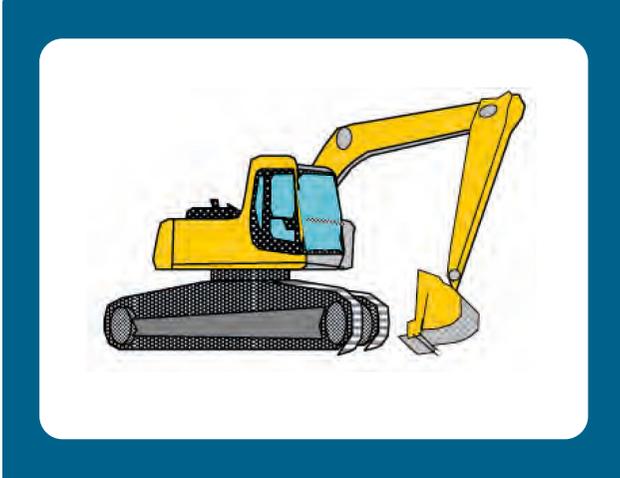
- Fill up the fuel tank at the end of the day
- Drain water and sediment from the fuel tank during start up inspection



### Key point

When a machine is parked with the fuel tank almost empty, air inside the tank cools off and condenses into droplets of water, which drip into the fuel. Therefore, fill up the fuel tank at the end of the day and drain water and sediment from the fuel tank at the start of the day.

## 4. Undercarriage (Hydraulic Excavator) Maintenance for Fuel Savings



### Remove mud

If mud has got stuck in the undercarriage, it increases travel resistance, which leads to worse fuel efficiency. Remove mud as often as possible.

### Adjust track shoe tension

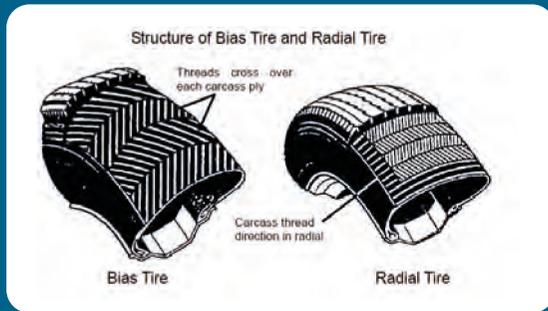
If proper track shoe tension is not maintained, it increases travel resistance, which causes higher fuel consumption.

Contact your local depot if you need to adjust the track shoe tension of your machine.

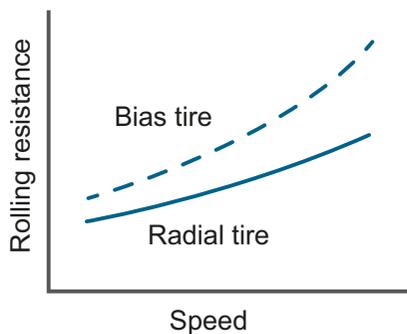
# 5. Tyres (Wheel Loader & Dump Truck) Maintenance for Fuel Savings

## 5.1 Tyre

- Use radial tyres



Comparison of rolling resistance

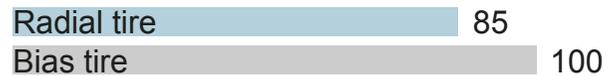


## Key Point

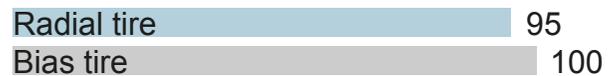
There are two kinds of tyres: a bias tyre and a radial tyre. Radial tyres have less rolling resistance and less fuel consumption than bias tyres by 5% to 15%.

## Example of comparison of fuel consumption for a dump truck

Dam construction site (one way 6.5km)

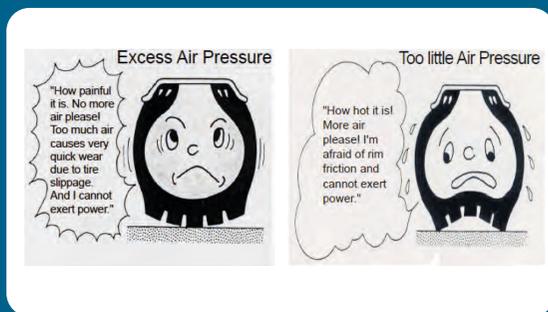


Limestone quarry (one way approx. 800m)



## 5.2 Tyre Pressure

- Check tyre air pressure during start up inspection when they are still cool so that proper air pressure is maintained at all times



## Key Point

A tyre supports the load with its internal air pressure. Therefore, it can not adequately demonstrate its inherent performance, or has a shorter tyre life, if the internal air pressure is higher or lower than specified. In particular, when the air pressure is lower, tyre rims can often incur friction that will cause a problem.

## Example of comparison of fuel consumption for a dump truck

Dam construction site (one way 6.5km)



Limestone quarry (one way approx. 800m)



# 6. Oil Maintenance – Maintenance for Fuel Savings

## 6.1 Oil Viscosity

- Use the manufacturers recommended oil

### Key point

To lubricate various parts of the engine, oil needs to have adequate viscosity. As oil viscosity can largely be affected by ambient temperatures, oil needs to be replaced for another kind that is better suited to the prevailing temperature. When oil viscosity is too high, it not only invites more friction resistance and more fuel consumption, but also causes seizure and rapid wear of parts. This results in bad startability of the engine. Conversely, when oil viscosity is too low, oil will overheat and oil film will be lost, which eventually results in higher oil consumption.

Reservoir	Fluid Type	Ambient Temperature										Recommended Fluids			
		-22	-4	14	32	50	68	86	104	122	°F				
		-30	-20	-10	0	10	20	30	40	50	°C				
Engine Oil Pan	Engine Oil													EOS0W30	
															EOS5W40
															EO10W30-DH
															EO15W40-DH
															EO30-DH

Refer to the operation and maintenance manual for the detail recommendation of oil usage.

# 6. Oil Maintenance – Maintenance for Fuel Savings

## 6.2 Oil Replacement Interval

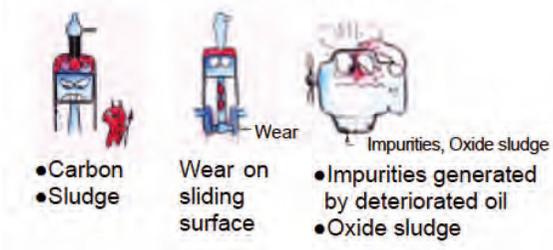
- Replace the engine oil and filter elements periodically in order to minimise engine failure and optimise fuel consumption

### Key point

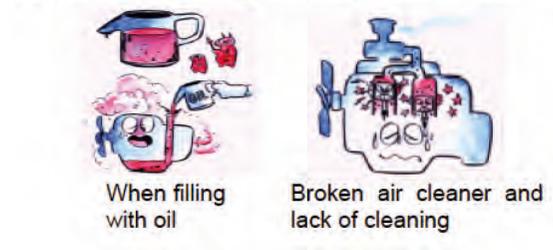
Engine oil has five functions: lubrication, cleaning, cooling, oil tightness and rust inhibition. As the time of use wears on, these properties become lower or deteriorate. If it is used beyond the specified time of replacement, it will rapidly lose those properties because of generated heat and impurities like oxide, carbon and sludge. All of these, combined, will result in shortening the life of an engine, not to mention higher consumption of fuel.

Meanwhile, engine oil circulates inside the engine to lubricate each part. It is vital that engine oil remains clean. For this reason, if an oil filter, which catches dirt and impurities in the oil (both getting in from the outside and generated inside) does not work properly, that leads to parts seizure and an even shorter engine life.

Dirt and impurities generated inside



Dirt and impurities generated from outside



## Always Remember to Operate**SAFE**



## 7. Management for Fuel Savings

### Maintenance for Fuel Savings

Monitoring operations can help determine whether fuel consumption is high or low. However, in the case of high consumption, it does not help identify the cause.

Even if a dump truck is running along the same hauling road, fuel consumption can vary depending on the operator's way of driving and various other prevailing conditions like machine maintenance and road surface. Thus, it becomes necessary to keep a clear record of all factors relating to dump truck operation so that when fuel consumption goes up, the cause for the deterioration can be identified and the proper action can be taken.

Find out more about the Flannery telematics dashboard, developed with technology partner MachineMax by scanning this QR code.



### An example of fuel management on Dump Trucks

Truck No.	Date of operation	Weather	Load	Hauled volume (ton)	Driving course	Tacho chart	Operation hours (H)
505	2017.4.10	Clear	Sand and earth	3640	A		8
505	2017.4.11	Rainy	Sand and earth	2912	A		8

(Continued) 2017.4.11

Hauling Distance (km)	Fuel consumed (L)	Driver's name	Per-hour fuel consumption (L/H)	Per-hour hauled volume (Ton/H)	Per-ton fuel consumption (L/ton)	Per-liter hauling distance (km/L)
40	130	Z	16.2	455	0.036	0.31
32	102	Z	12.7	354	0.035	0.31

Analyse dump truck operation records using a revolving tacho chart and utilise results of the analysis to train operators using telematic data for better fuel savings.

### Points to be checked

1. Is the travel speed too high? Check if the travel speed has not exceeded the speed limit, or the operator has not run faster than other operators do.
2. Does the travel speed change too often? When a travel speed changes too often, so does the engine speed.

## For More Information:

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