Whitepaper:

EU Stage V Emission Standards

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Introduction

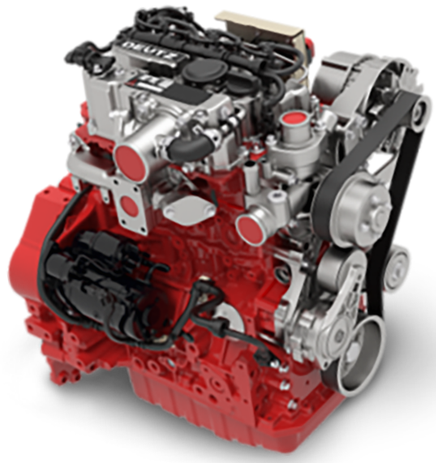
At the start of 2019, new EU emission standards (Stage V) came into place across a variety of applications and power classes. Speaking specifically to Mobile Elevating Work Platforms (MEWPs), the impact is significant as most engine-powered boom lifts fall within the affected 37≤ to 56<kw class. Similar to recent emission standard changes, the main objective is to further reduce particulate and nitrous oxide (NOx) emission levels, however in these most recent changes there are specific limits on the number of particulates. By following the status quo, it is impossible to meet Stage V requirements on 40ft booms without adding an engine equipped with a DPF. However, by leveraging the efficiencies of our AXLDRIVE™ system and staying true to our simply reliable philosophy, Skyjack found a way.

The Right Engine, The Right Way

Skyjack has always approached emission changes from the standpoint of engineering a solution that is dedicated to protecting our customers' ROI. It was this stance that resulted in our first SMARTORQUE™ machines with our 74hp North American telehandlers in 2015. The first of their kind supporting US EPA Tier 4 Final regulations with no Diesel Exhaust Fluid (DEF) requirement, a stance soon adopted by other manufacturers. SMARTORQUE™ will also ensure that Skyjack will have a full range of Stage V compliant rough terrain scissor lifts without the use of active aftertreatment later this year.

After the Stage V standards were approved many manufacturers went to their suppliers and started stocking up on existing engines, which would extend the production life cycle of their existing products. Skyjack did consider this option, however change was inevitable, so we chose to face this change head-on rather than prolong the process. There are numerous environmental reasons why this directive was approved, and Skyjack made the decision to be one of the first manufacturers to be compliant.

This decision was made in part to speed up our compliance timeline, as well as to position Skyjack as the equipment of choice for companies looking for a compliant option in 2019. Depending on how strict a region's enforcement of Stage V compliancy is, rental companies will face less barriers renting Skyjack booms as they are compliant sooner than others.



Stage V Deutz D2.2 diesel engine

The Stage V Boom Effect

Unlike previous engine emission changes, the adoption of Stage V regulations does not provide the opportunity for flexibility (flex) engines. Any engine manufactured in 2019 must be compliant with the new regulations. Any inventory of engines manufactured before 2019 must be consumed by equipment manufacturers within 18 months, and within the market over another six months.

When looking at the power classes within the <56kw class, there are two important things to note:

1. Engines within the 19≤ to <37kw class did not previouly feature any additional exhaust after-treatment, so those are jumping straight from Stage IIIA to Stage V. Engines within the 37≤ to <56kw range were previously equipped with a Diesel Oxidation Catalyst (DOC) following the implementation of Stage IIIB emission standards. What does this mean? Engines within the former engine power class are seeing a significant increase in cost as they're going from no after-treatment at all, straight to a DPF.
2. Particle Number (PN) emission limits are not being applied to engines in the <19kw range. While they do have specific NOx and Particulate Matter (PM) requirements, no PN limit avoids the need for a DPF. While there is an increase in cost to switch from the Stage IIIA compliant air-cooled 36kw engine to the Stage V compliant liquid-cooled 18.5kw engine, it is less than 20% of the cost to add a DPF.

Taking these two points into consideration was important for Skyjack when looking at selecting the appropriate Stage V engine for its SJ46 AJ, SJ51 AJ, and SJ45 T models. Heading into 2019, all three of these models were outfitted with a 36.5kw Stage IIIA engine, which meant a significant cost jump to Stage V. Skyjack recognized that while everyone can appreciate this increase is dictated by a required change to emission standards, it isn't feasible for this cost to be passed onto our customers, and then expect them to recoup that through increased rental rates. So Skyjack looked into alternatives.

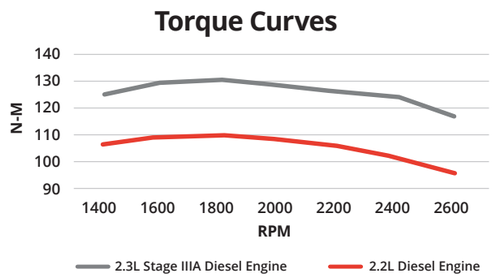
At face value, it may seem quite drastic to switch from a 36kw engine down to an 18.5kw engine, but Skyjack saw potential value in investigating its feasibility. When switching to an engine with nearly half the power, there will obviously be some tradeoffs. Skyjack wanted to see if those tradeoffs could be minimized, and if the positives could clearly provide benefits over any performance losses.

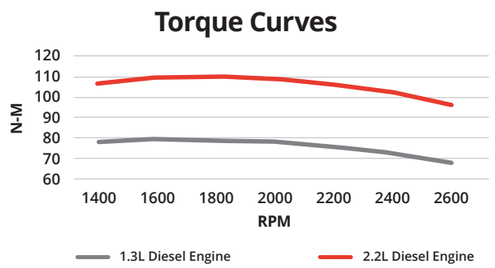
Investigative Findings

Extensive testing and investigation was done on each model to see what the impact would be on drive speed, function speed, rough terrain driving, and various environmental conditions (temperature and altitude). Through these investigative efforts the only tradeoff was to drive speed.

Impact to tractive effort performance was minimized as a result of utilising a 2.2L engine versus a 1.3L engine, which is commonly used in this power class, and combining it with the minimal loss of efficiency through Skyjack's axle-based drive train AXLDRIVE™. Theoretical comparisons aside, Skyjack performed a head-to-head comparison with all affected models – 36kw Stage IIIA vs. 18.5kw Stage V – on a variety of surfaces in different conditions.

Machines were operated on hard flat surfaces, rolling compact dirt, loose soil, mud, snow, as well as 45% grades on both hard surfaces and loose soil. From an operator's standpoint, the difference was negligible. This means that in reality, when navigating an actual job site, the difference will be slight. Yes, driving on flat ground at top speed will be noticeable, but when navigating rough terrain on a typical job site, performance will be similar to what it is today.





When evaluating function speed performance, individual speeds were evaluated with no change to times, while multifunctioning up to three functions at a time showed minimal change – less than 5 seconds, when cycling through a full range of motion. This was performed at both ambient temperature and with cold hydraulic oil at -10°C.

Further performance benefits of the 2.2L engine are increased fuel economy and minimal loss of power at altitude – however the latter is only 3% at 1,600m altitude vs. upwards of 20% on a 1.3L displacement engine. While fuel type acceptance may vary by make and model, the engine that Skyjack has selected supports 2,000 ppm sulfur content – making machines equipped with it available for export to other regions that have low sulfur fuel (vs. ultra-low sulfur).

While the importance of minimizing the impact to performance cannot be overstated, as mentioned earlier, the main driver behind making this change was to mitigate the ripple effect of increased costs. The savings associated with using an 18.5kw engine are financially sensible for Skyjack, its customers, and end users. It also saves time as machines equipped with this engine avoid the maintenance associated with additional after treatment.

The Impact of DPF on Your Machine

The addition of a DPF is a significant cost burden on the engine and subsequent machine it's placed in. But what does it do, and what costs are associated with it?

When looking at the after-treatment system of an engine equipped with a DPF, the system is performing all of the functions that the DOC did – oxidizing hydrocarbons, carbon monoxide, and unburned fuel/oil – while also trapping the remaining soot that would have passed through the DOC. The soot remains in the DPF until it is regenerated either passively or actively. Passive regeneration will occur under the machine's normal operating temperatures, invisible to the operator. Once the soot accumulation reaches a certain level, the machine will require an active regeneration with the machine in a standstill state. The engine temperature is then significantly increased to burn off the trapped soot.

Every engine is different and the DPF process is managed differently from one manufacturer to the next, however at a high level, they are performing similar processes. Initially the machine is operated as it normally would, eventually passive regeneration will occur while the engine is running (under load or not). Following the passive regeneration, and after more soot accumulates, the operator will be notified that the machine requires an active regeneration cycle. The operator has the option of ignoring the active regeneration, however the engine performance will eventually get downgraded. If the active regeneration is ignored long enough, not only will performance continue to decrease, but eventually, a state will be reached where the engine manufacturer will need to service the engine or the DPF will fail.

If the DPF fails there are two options:

- Replacement of the DPF
- or, more likely, complete replacement of the engine

The cost associated with either of these two scenarios vary among engine manufacturers, but suffice to say it is significant.

How often will an active regeneration cycle be required and how long does it take? Again, there will be some variance from one engine model and manufacturer to the next, and there are external factors to consider as well. Depending on the application and environment the machines are being used in, it is possible for a boom lift to be operated for more than 150 hours before requiring an active regeneration, with passive regeneration keeping the DPF clean of significant soot buildup over a prolonged period of time. When an active regeneration cycle is required, the machine will need to be placed in a standstill mode for anywhere between 40-50 minutes (make and model dependent). During this time the machines will be inoperable – and if the regeneration cycle is interrupted, it must be restarted from the beginning.

Leading the Change

With Stage V emission-compliant machines now entering the European market, MEWP owners are faced with several changes to the equipment they purchase moving forward. A significant part of these changes undoubtedly affect their bottom line – from the cost of initial acquisition, to the cost of ownership. Mitigating that impact while minimizing impact to performance was an important consideration when Skyjack made its decision to use an 18.5kw engine for the smaller engine-powered booms. Yes, there are tradeoffs – a slight decrease in performance traded for a significant avoidance in costs and downtime. The job site you could previously navigate with no issues, can still be navigated with no issues.

Skyjack is leading the change towards Stage V compliance and our booms will be ready for the market before any other manufacturer. Full spec sheets outlining changes made in conjunction with Stage V are available online at skyjack.com.

Notes

Notes

SMARTORQUE™

STAGE V

DESIGNED FOR RENTAL

SMARTORQUE™ utilises AXLDRIVE™ together with high torque engines and simplified, high efficiency hydraulics to deliver the necessary torque and performance found in larger engines. This provides the benefit of lower acquisition costs and the employment of minimal emission controlling modules that otherwise are both expensive and complicated.

SMARTORQUE™ means no diesel particulate filter (DPF), no diesel exhaust fluid (DEF), and no other active exhaust after treatment on standard engines for **Stage V** Emission regulations. While there is a 12 month transition period for **Stage V**, certain local governments have stricter enforcement policies. Skyjack took the view that a truly compliant machine will allow rental companies to supply these often problematic areas. Applies to European SJ45 T, SJ46 AJ and SJ51 AJ models.

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simply reliable