

TIER 4 ENGINES PRELIMINARY FINDINGS

HOW TIGHTER EMISSIONS
REGULATIONS ARE CHANGING
YOUR OIL & WHAT YOU CAN DO
ABOUT IT

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EXECUTIVE SUMMARY

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Since 1996, off-road diesel engine applications have been regulated under tighter emission standards from the Environmental Protection Agency, Environment Canada & the European Union which have led manufacturers to force emission particulate into the engine oil. The emission standards have gotten tighter over the years and have culminated, in January 2015, in the Tier 4 Final emission standards being enforced across North America in ALL newly manufactured diesel engines.

For this preliminary study, Fluid Life analyzed over 22,000 oil samples from the 2 models of engines with the highest populations of Tier 4 classifications. Overall, the Tier 4 engines performed better than expected. In most cases, the addition of the tier classification reduced alarm limits. Reducing alarm limits increases your company's potential for improving engine life, improving reliability (by improving oil cleanliness) and decreasing life cycle cost (by alerting potential failures earlier). Some reasons for the improved cleanliness are the additions of spinner filters, diesel particulate filters and diesel oxidative catalysts, a more efficient turbocharging and injector system, more stringent oil change intervals and better reliability practices from each of your sites.

To ensure the best reliability, make sure your equipment gets the recommended oil & filter changes done on a timely basis, that idling is minimized whenever possible and that tier information of all equipment is being provided to Fluid Life.

Please note that for statistical validity, each calculated limit has a minimum of 500 samples. As population sizes increase and more engine models are added, Fluid Life will update its alarm limits as well as this report. Please note that the 99th percentile limits are presented in this report in a descriptive manner only.

If your company is interested in employing the improved alarm limits, please contact your Fluid Life sales representative for further information.

Fluid Life is proud to be your partner in your goal of increased reliability and we encourage feedback from our customers. If you have any questions, comments, concerns, please feel free to contact your sales representative at any time.

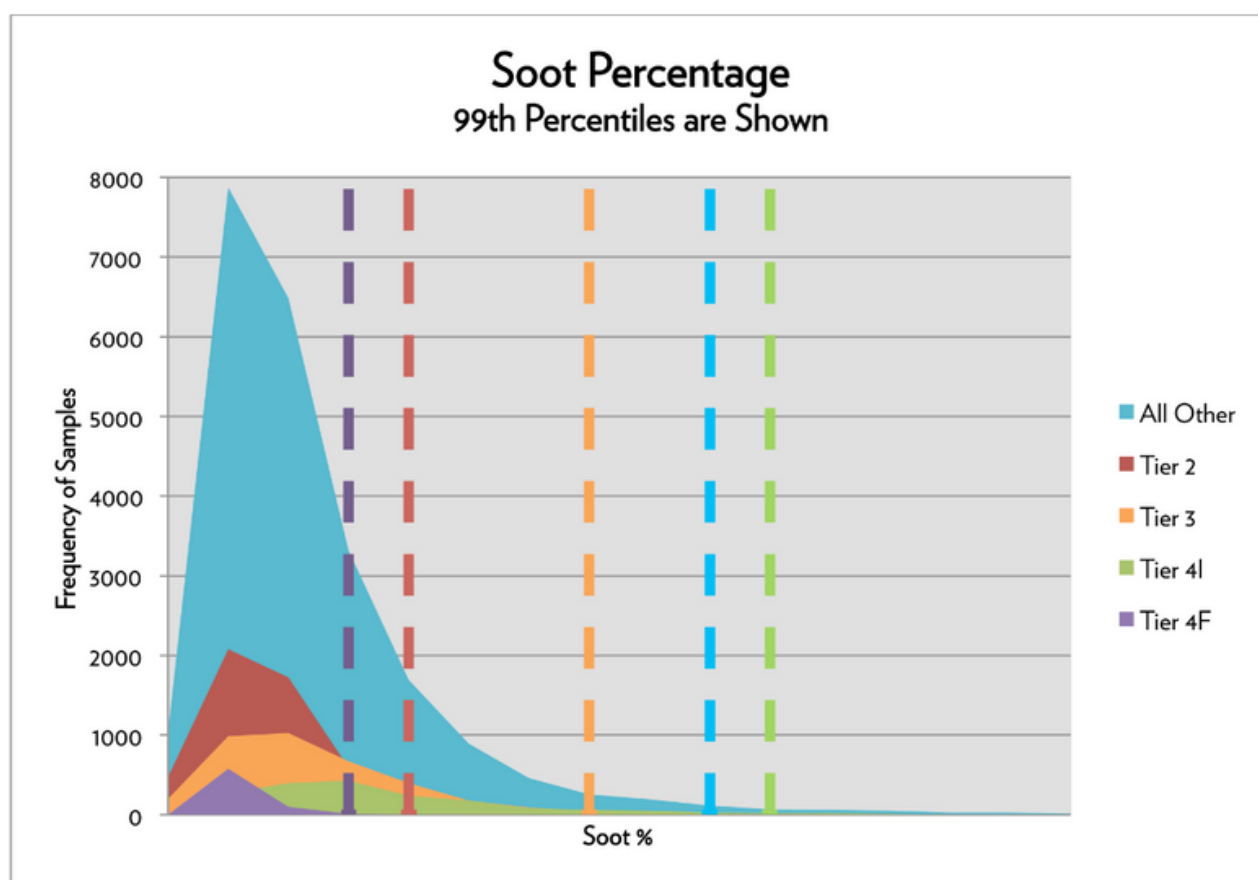
TIER 4 ENGINE RESULTS

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Soot

In order to reduce emission particulate, some manufacturers redesigned their engines to add a portion of the exhaust gas back into the combustion chamber. After learning about the redesign, Fluid Life's primary concern was an increase in soot in the engine oil, causing damage to the engine. Our analysis shows that, in some cases, soot is indeed increasing in these models of engine, although not to exceedingly high values (the 99th percentile for each engine tier is less than 2% soot).

In the case of these particular models, using non-tiered limits would flag Tier 4 Interim engines too often and may miss potential issues in the other models. Please note that the Tier 4 Final group has the smallest sample size (~600 samples) and will be updated as the population of oil samples grows.



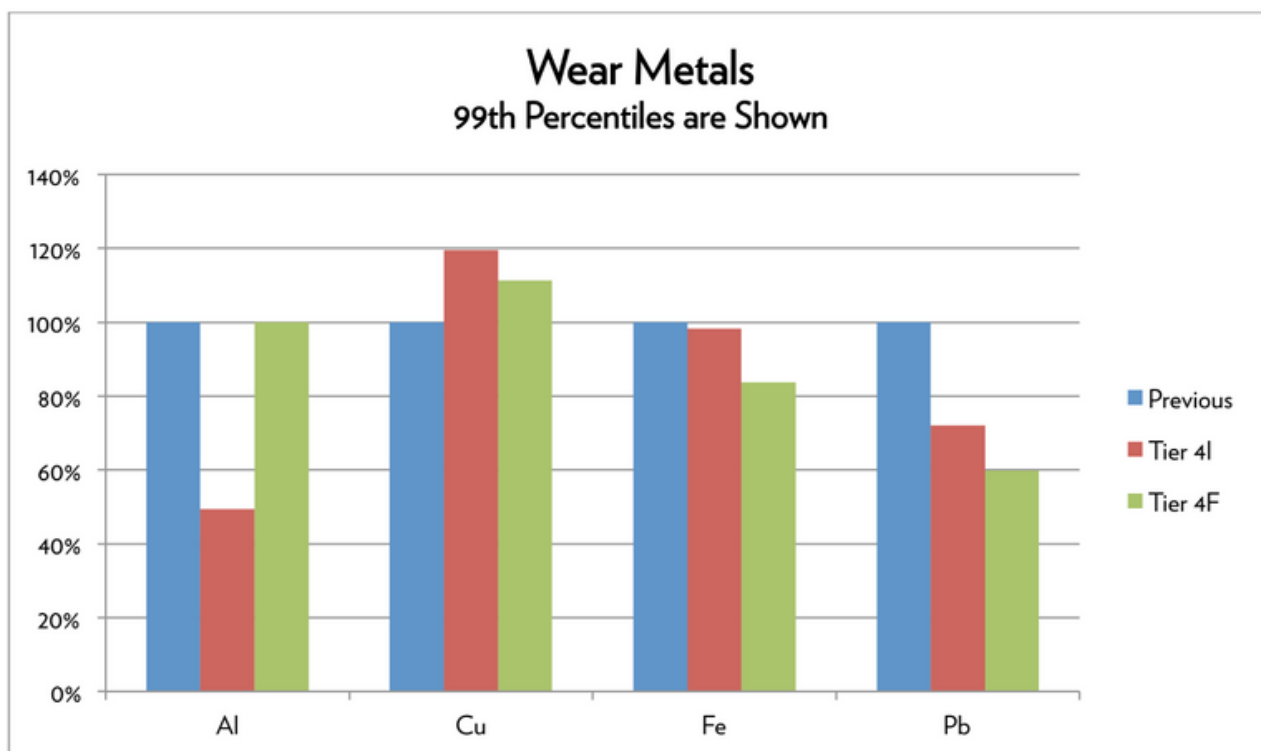
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Wear Metals

In general, the Tier 4 engines generate less wear metals than their counterparts. Outside of copper, all 99th percentiles show a decrease from non-tiered groupings. The increase in copper is potentially caused by rocker arm wear, break-in wear on new engines or from cooler core leaching, as most of the Tier 4 engines in the analysis are relatively new.

Potential reasons for the improved cleanliness are stringent oil and filter changes at 250-300 hours and the additions of spinner filters.

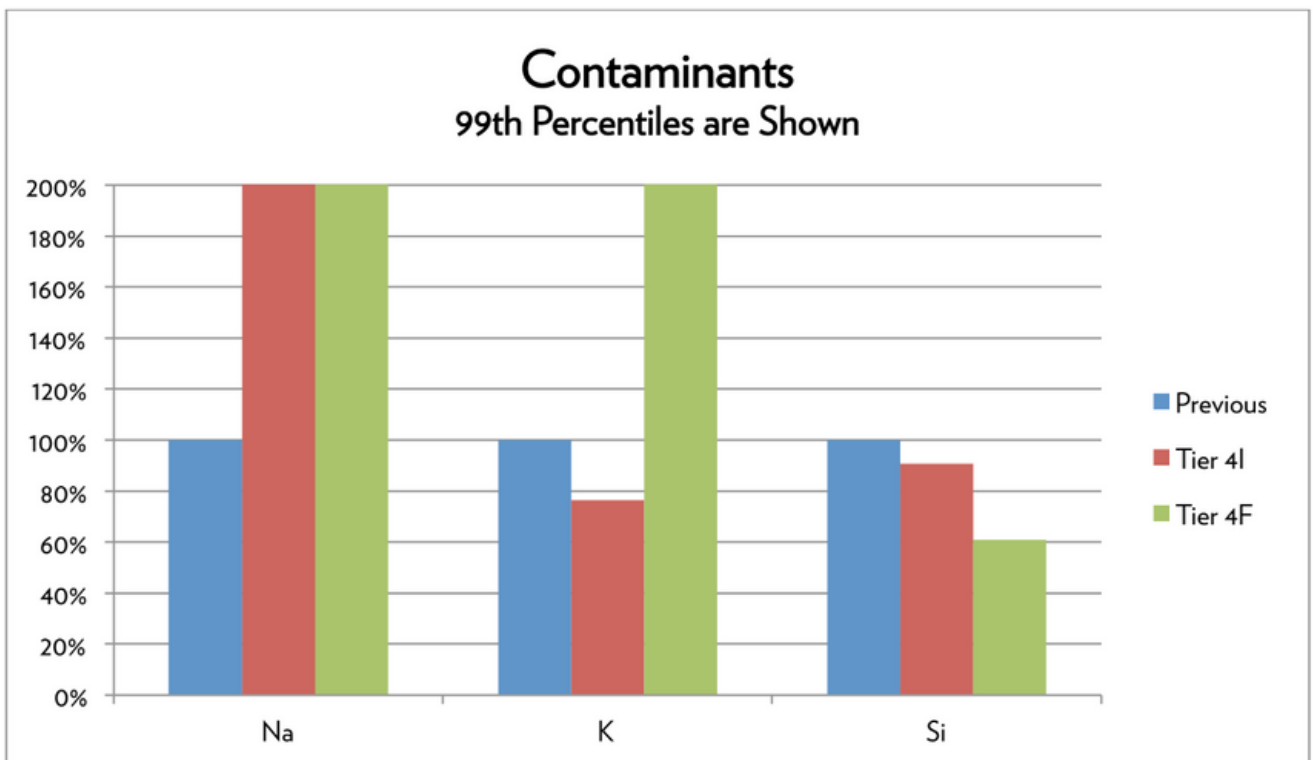


TIER 4 ENGINE RESULTS

Contaminants

With one of the models analyzed, the data displays a small increase in the amount of silicon in the Tier 4 Interim engines. This may be residual impact from the sealant used during manufacturing, silicon leaching from seals & gaskets in the factory fill oil or other sources but it is unlikely to be from dirt. However, from an overall perspective, there is minimal impact to the 99th percentile.

For one of the models in both Tier 4 Interim & Final engines, there were a number of top-end coolant leaks which caused a large amount of sodium and potassium to be found in the oil samples. A possible cause for the increased risk of coolant leaks is the addition of an EGR cooler (which is also glycol cooled), adding more area for damage (and therefore leaks). For both potassium & sodium, Fluid Life will NOT be altering its alarm limits. Please note for the contaminants, for clarity, the author truncated the Y-axis at 200% as the sodium and potassium values were significantly larger (over 8,000% of previous limits).



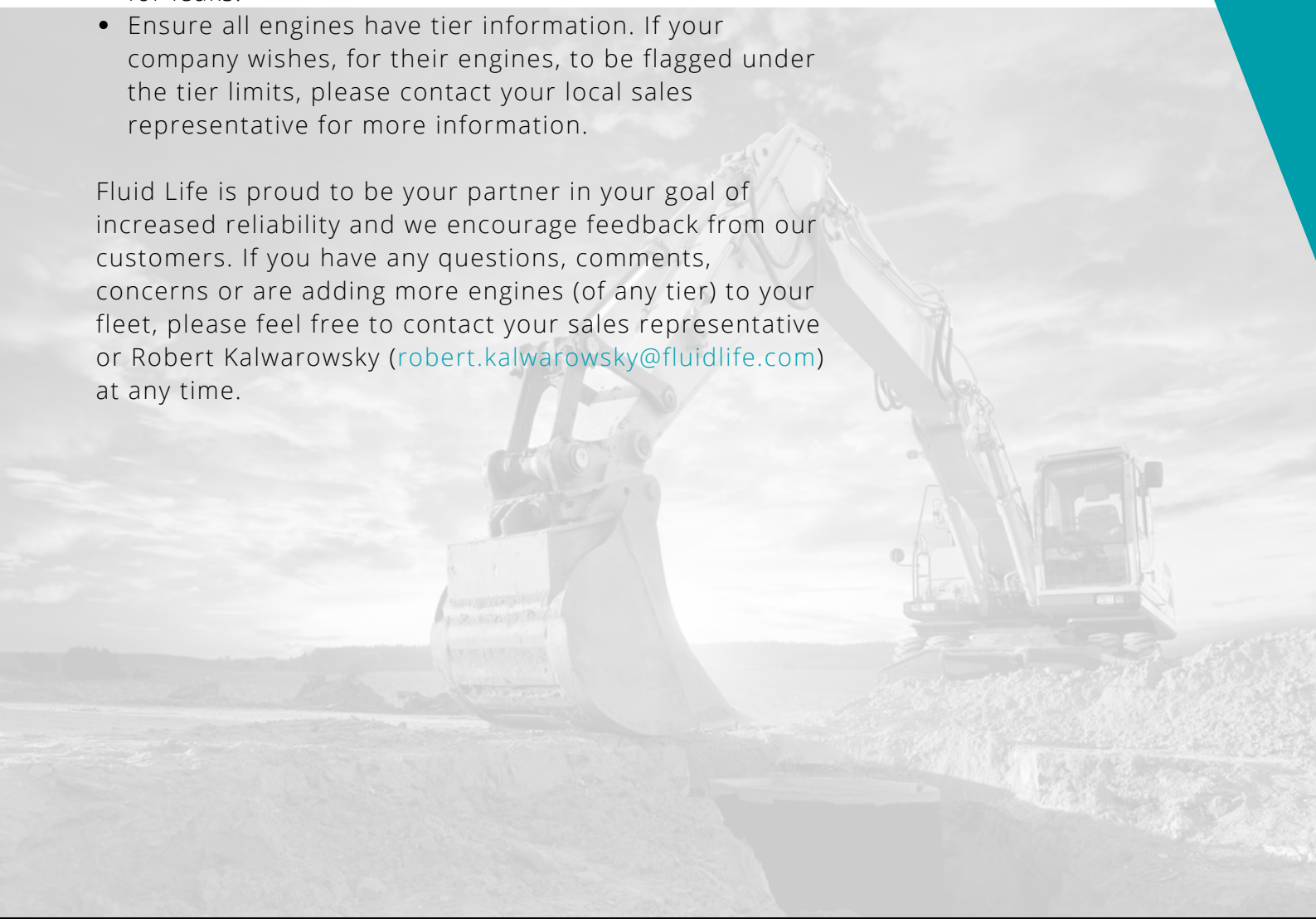
RECOMMENDATIONS

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Overall the Tier 4 engines performed better than expected. In most cases, the addition of the tier field reduced alarm limits, increasing your company's potential for improving engine life, improving reliability and reducing life cycle costs. The following recommendations have taken into account the analysis above as well as other literature on Tier 4 engines.

- Ensure oil & filter changes (including the DPF filter) occur at or before OEM recommended intervals. Doing so will prevent the buildup of soot, dirt, dust or wear metals.
- If possible, idling should be limited to prevent a buildup of soot.
- Ensure that regeneration of DPFs is performed when needed to reduce the buildup of soot.
- Check oil analysis results for potassium & sodium without glycol. If this is the case, in addition to regular troubleshooting practices, check the EGR cooler system for leaks.
- Ensure all engines have tier information. If your company wishes, for their engines, to be flagged under the tier limits, please contact your local sales representative for more information.

Fluid Life is proud to be your partner in your goal of increased reliability and we encourage feedback from our customers. If you have any questions, comments, concerns or are adding more engines (of any tier) to your fleet, please feel free to contact your sales representative or Robert Kalwarowsky (robert.kalwarowsky@fluidlife.com) at any time.



DISCLAIMERS

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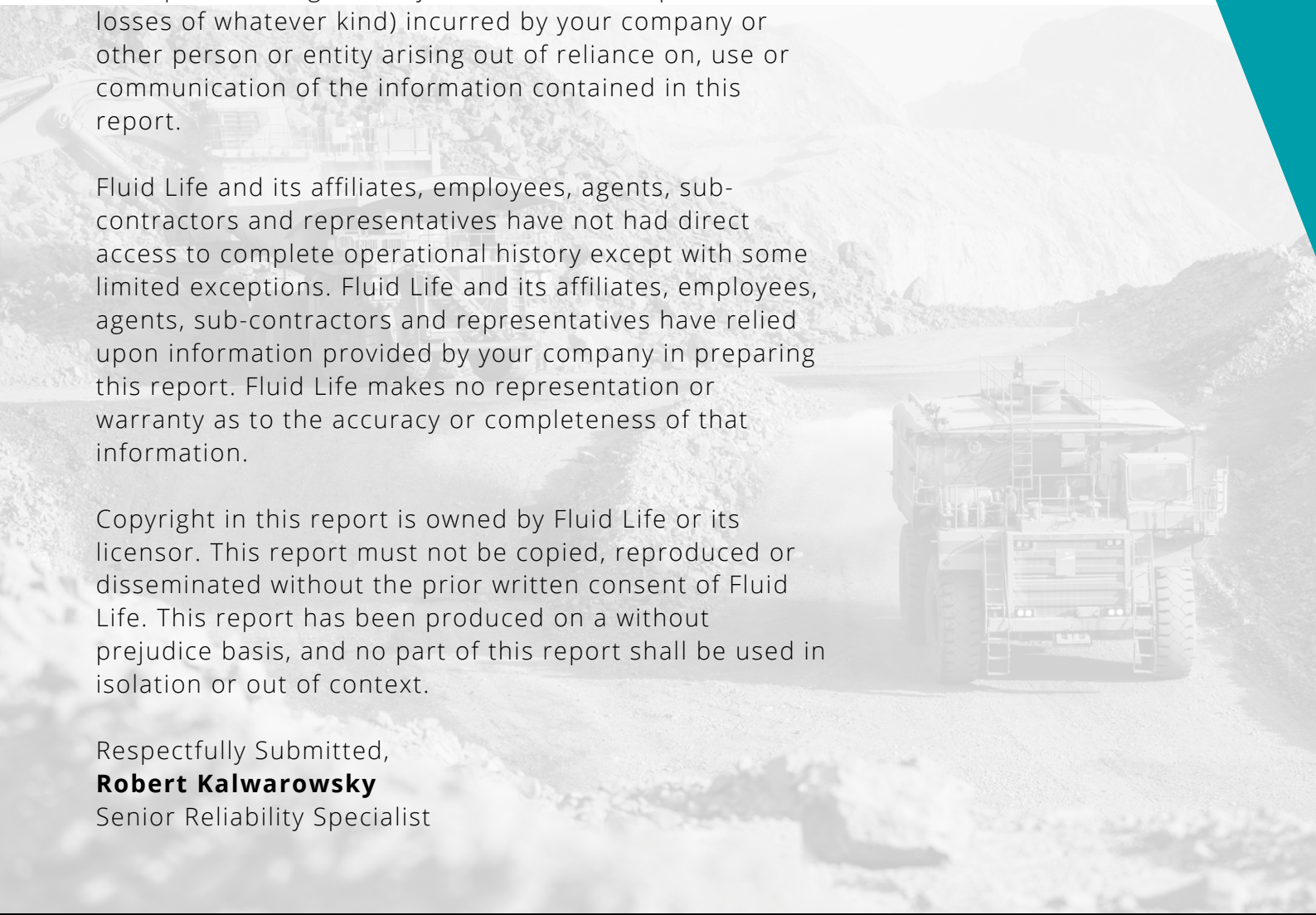
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Respectfully Submitted,
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Senior Reliability Specialist



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