



BHP Mitsubishi Alliance

RSHQ SRM KSN D11 WBV Presentation

13/11/2025

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Saraji KSN Dozer WBV update

Context

What is WBV (Whole Body Vibration)?

Whole body vibration (WBV) refers to the exposure of the entire body to mechanical vibrations, typically through a vibrating platform or machine. Prolonged exposure can have negative effects such as, Musculoskeletal Issues, Nervous System Impact, Cardiovascular Stress.

Since their initial deployment in 2021, D11 dozers with the KSN prefix have exhibited persistent issues related to whole-body vibration (WBV) and rough ride quality, particularly at the Saraji mine site. These concerns have been consistently reported across multiple operational areas, with the KSN series emerging as the most problematic variant when compared to other D11 models.

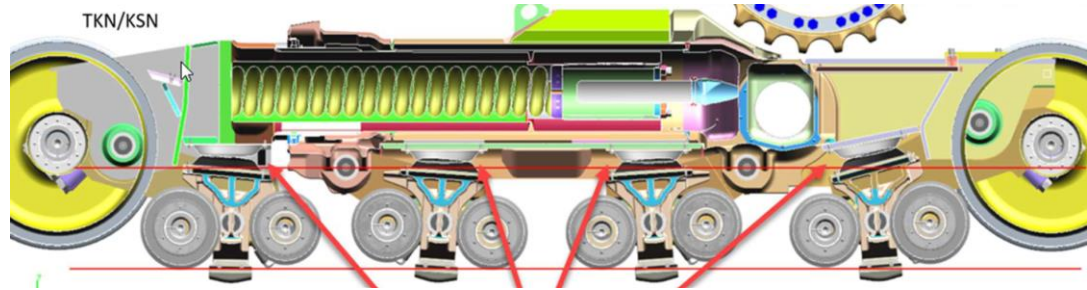
Operator feedback regarding ride quality has been inconsistent and often lacks the granularity required for precise root cause analysis. The complexity of the issue is compounded by the multifactorial nature of WBV, which involves a wide range of mechanical, operational, and environmental variables. These include, but are not limited to, undercarriage dynamics, cab mounts, terrain variability, and machine operating conditions.



Summary of KSN Dozers

Changes from previous models

- Weld on fender crossbeam
- Case and frame design
- Load sensing hydraulics
- Cab displays
- Torque converter- Stator Clutch
- Stiffer equalizer bar – These are also used on later AMA Dozers Onsite
- A/C condenser on the roof – lower natural frequency/cab mount loads
- Sold with HDXL Duralink 6mm crowned links vs 6T Flat HD links on AMAs
- Premium operator's seat - less cushion w/ heated & a/c version compared to AMA Dozers
- Undercarriage configuration – Types of rollers used – High Abrasion vs Standard Arrangement



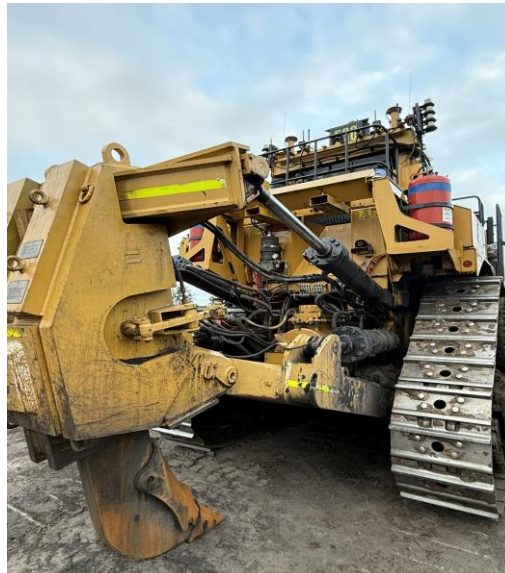
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Original Premium Seat



What has not changed

- SS Ripper
- Track frames
- Idlers
- Bogie pads
- Wear package on blade



Investigation Items

Seat condition- correct adjustment / interference

- What complaints did operators have?
- Seat changeout strategy



ab mounts- durability rubber deterioration

- Current production part- fit for purpose
- Caterpillar testing – ISO standards- comparison vs stiffer mount



ogie pads- rubber deterioration- excessive loading

- Rubber durability to spec
- Loading points
- Bonding

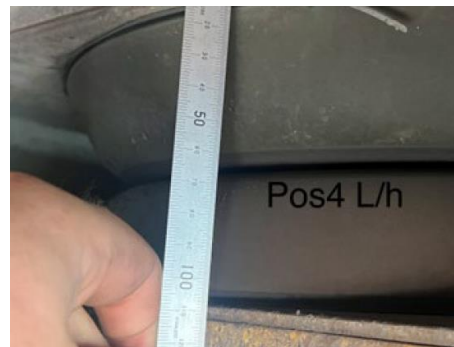
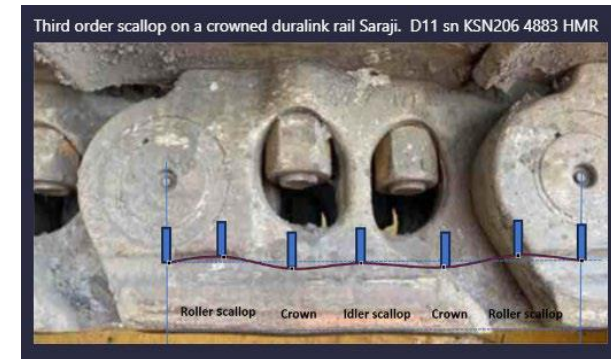


ack, Idler & roller wear

- Track scalloping – roller / idler scallop- affect of pitch frequency
- Correct idler height- affect on machine dynamics
- Roller wear- faster wear on Roller 1,2,3- effect on machine weight / dynamics

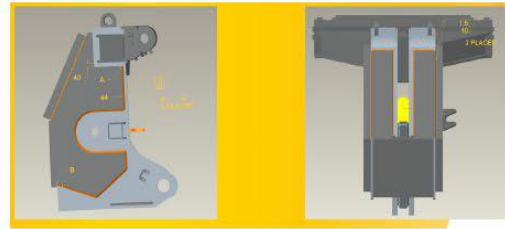
ogie stack heights

- Measurement of 'crush' to determine weight
- Caterpillar in field testing
- Procedure development

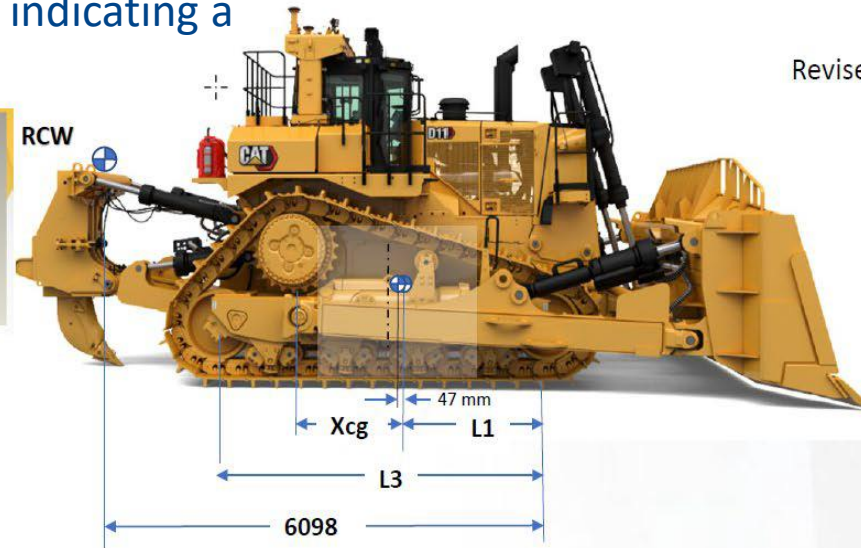


KSN D11 Blade and Ripper box Information

- Saraji KSN with wear package plates calculated at ~1000kgs
- Extra 1000kgs moves the Centre of Gravity forward 47mm
- Ripper box weight addition of 1150kgs to offset wear package weight has improved ride characteristics significantly, indicating a potential balance issue



1150 kg
Rear Cwt



	W	L3	Xcg	L1	DELTA	L1/L3
D11T AMA878	103516	4435.0	1357.7	1879.3	0.0	0.424
D11 KSN206	103873	4435.0	1364.7	1872.3	7.0	0.422
D11 KSN206 w/1000 kg XTRA BWP	104873	4435.0	1404.8	1832.2	47.1	0.413
Target	-	4435.0	1357.7	1879.3	0.0	0.424

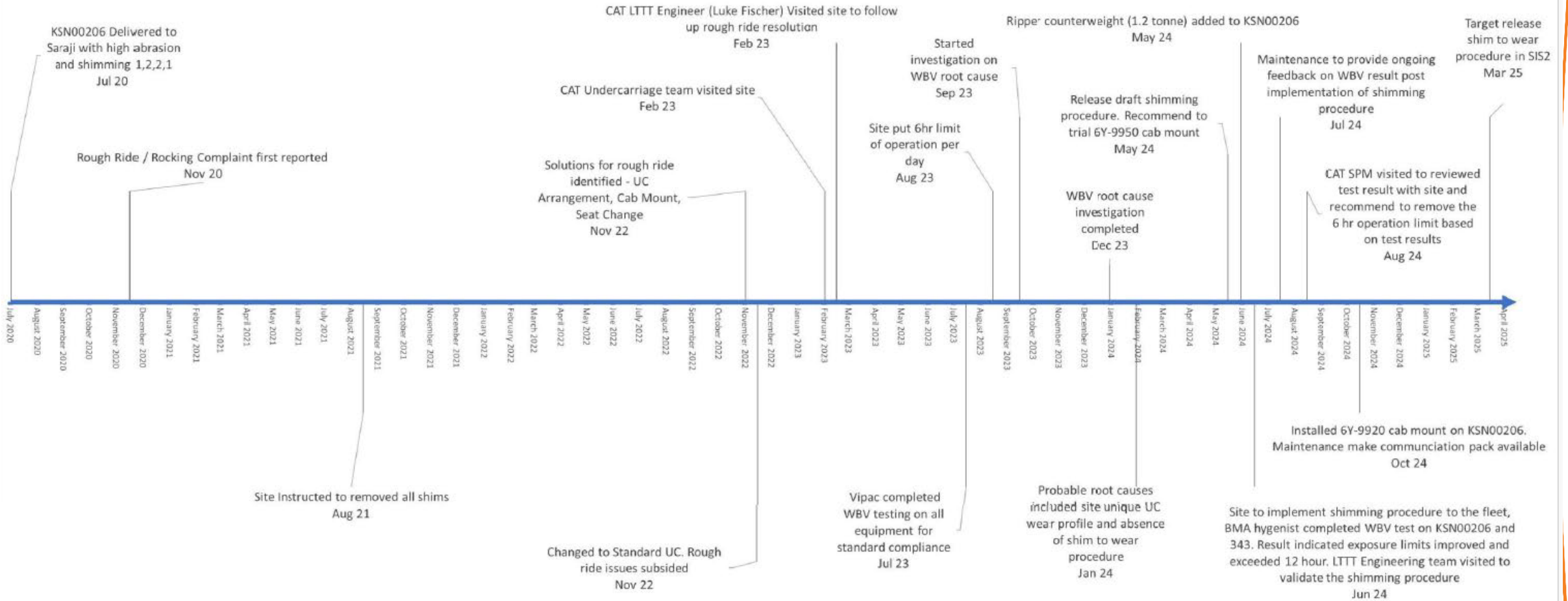
$$\begin{aligned}
 \text{RCW} &= W(L1' - L1) / (d - L1') \\
 &= 104873 \text{ kg} (47.1 \text{ mm}) / (6098 \text{ mm} - 1879.3 \text{ mm}) \\
 &= \mathbf{1170 \text{ kg (2580 lbs)}}
 \end{aligned}$$

$$\begin{aligned}
 W &= 104873 \text{ kg} \\
 L1 &= 1832.2 \text{ mm} \\
 L1' &= 1879.3 \text{ mm} \\
 d &= 6098 \text{ mm}
 \end{aligned}$$

Total KSN Machine Wt. w/ RCW = 106044 kg (233827 lbs)



Timeline



Ride Quality

WBV

Saraji KSN Dozer WBV update

What has been done

Maintenance and Engineering Enhancements

- Maintenance activities are being executed in accordance with BMA's enhanced PM02 strategies, which exceed OEM baseline recommendations. These strategies emphasize components and systems known to influence whole-body vibration (WBV) and ride quality. A dedicated section has been incorporated into the service documentation to capture undercarriage dimensional data, enabling trend analysis and early detection of deviations.
- Originally, BMA KSN dozers were equipped with a high abrasion undercarriage group from the factory. These have since been replaced with conventional undercarriage groups.
- To optimise performance, a newly developed bogie stack height adjustment procedure has been implemented by the maintenance team. This procedure was developed in conjunction with BMA, Caterpillar USA and Hastings Deering and has been rolled out to all BMA sites and is available within CAT SIS.
- Balance assessments are routinely performed following major undercarriage works to ensure compliance with OEM specifications and to maintain optimal ride dynamics.
- A trial seat has been installed in TRD542 and TRD539 to evaluate ergonomic and vibration-dampening performance relative to the factory-installed seat. Preliminary feedback has been mixed, and further data collection is ongoing.
- A comparative blade configuration trial was conducted involving a blade swap between DZ25 (Comiskey machine) and TRD530. The objective was to assess the impact of the BMA blade's additional wear package on machine balance and WBV characteristics. Data and operator feedback have been collected and can be seen in slides 10 and 11
- An extra counterweight plate has been fitted to the TRD539 to test if the extra weight improves the balance ratio
- All KSN machines have been retrofitted with upgraded cab mounts following the identification of premature failure in the original components. The new mounts are expected to enhance vibration isolation and improve operator comfort.
- Targeted clutch and brake pressure inspection/adjustments have been conducted across the fleet to address reports of harshness when turning or changing direction.



Saraji KSN Dozer WBV update



HSS team

- A structured PM02 vibration testing protocol has been developed and integrated into SAP. This strategy includes pre- and post-maintenance vibration assessments, particularly following major undercarriage interventions, to establish and monitor baseline vibration exposure levels
- A cumulative dosage tracking tool has been developed to aggregate WBV exposure data across multiple dozers and operator shifts. This tool enables a comprehensive assessment of operator exposure in alignment with occupational health standards
- Whole-body vibration assessments conducted on all KSN dozers during CY25 have consistently demonstrated that routine operational procedures result in exposure levels below the threshold defined by the EU Directive 2002/44/EC Limit Value. Detailed testing data is appended to the end of this slide deck for reference
- BMA HSS teams are developing a TARP to address vibration which will be published and distributed once complete

OEM

- OEM collaboration has been proactive. The on-site OEM representative has been instrumental in disseminating product updates and training materials to the workforce. Local Hastings Deering support personnel continue to work closely with maintenance teams to ensure that vibration testing and mechanical adjustments are performed in accordance with OEM specifications
- Caterpillar USA has finalized a bogie stack height adjustment procedure, which is nearing deployment. This procedure is expected to enhance undercarriage performance and reduce WBV transmission

Engineering

- Operational feedback continues to be collected across all teams, with consistent themes emerging that align with observations from BMA-operated Comiskey machines. Notably, these machines—maintained by BB Country—exhibit superior ride characteristics, potentially attributable to differences in blade wear package configurations
 - Recent focus has been placed on stockpile dozers, with constructive feedback from operators being relayed to both OEM and maintenance teams for action. A heavier counterweight solution is scheduled for implementation during the next major PM window on unit TRD539. This modification aims to improve ride dynamics by optimizing the machine's balance ratio



Cross-site engagement has been initiated to gather broader insights into WBV issues affecting KSN fleets. Feedback, meeting minutes, and action items from all fortnightly WBV review meetings have been transparently communicated with SSHRs and relevant workgroups

Saraji FY25 WBV Data

Routine Operation Assessment

Vehicle Type	Vehicle ID	Measurement Time (hh:mm)	a _{rms} max	VDV (8) max	Dominant Direction	Time to EAV (hh:mm)	Time to ELV (hh:mm)	Risk Score
Rear Dump Haul Truck								
CAT 793D	RD27	1:04:44	0.35	6.5	Vertical	>12	>12	Low
CAT 793D	RD28	1:06:12	0.32	6.3	Vertical	>12	>12	Low
Dozer								
CAT D11 Fusion	DZ25	1:11:57	0.83	15.1	Vertical	1:06	>12	Moderate
CAT D11 Fusion	TRD542	1:02:32	0.64	12.8	Vertical	2:00	>12	Moderate
CAT D11 Fusion	TRD539	1:07:10	0.59	13.7	Fore-Aft	1:36	>12	Moderate
CAT D11 Fusion	TRD544	0:55:54	0.9	18.9	Vertical	0:24	>12	Moderate
CAT D11 Fusion	TRD545	0:25:27	0.48	11.8	Fore-Aft	2:48	>12	Moderate
CAT D11 Fusion	TRD531	0:19:10	0.73	13.6	Vertical	1:36	>12	Moderate
CAT D11 Fusion	DZ24	0:56:56	0.77	14.4	Vertical	1:18	>12	Moderate
CAT D11 Fusion	TRD540	1:24:36	0.64	13.6	Fore-Aft	1:36	>12	Moderate
CAT D11 Fusion	TRD543	0:36:02	0.62	15.6	Fore-Aft	0:54	>12	Moderate
CAT D11 Fusion	TRD541	1:56:48	0.9	16.9	Vertical	0:42	>12	Moderate

Evaluation method	EAV	ELV
a _{rms}	0.5 m/s ²	1.15 m/s ²
VDV (8)	9.1 m/s ^{1.75}	21 m/s ^{1.75}

Risk Criteria	Risk Score	Evaluation Criteria
More than 12 hours required to exceed both EAV/ELV	Low	a _{rms} < 0.5 VDV (8) < 9.1
EAV reached in less than 12 hours, but more than 8 hours required to reach ELV	Moderate	0.5 < a _{rms} < 1.15 9.1 < VDV (8) < 21
ELV reached in less than 8 hours	High	a _{rms} > 1.15 or VDV (8) > 21

All WBV measurements found vibration exposure level Risk Scores to be Moderate or Low in all vehicles monitored during FY25 at Saraji when operators were performing routine operations.

Saraji FY25 WBV Data

OEM vs. Extra Wear Package - Blade Swap Trial TRD530

Blade Type	Task Observed	Measurement Time (hh:mm)	a_{rms}			$a_{rms\ max}$	VDV (8)			VDV (8) max	Dominant Direction	Time to EAV (hh:mm)	Time to ELV (hh:mm)	Risk Score
			X	Y	Z		X	Y	Z					
Extra Wear Package	Tramming 1 st Gear	0:16:27	0.54	0.53	0.59	0.59	9.1	7.6	7.6	9.1	Vertical & Fore-Aft	5:42	>12	Moderate
OEM (No package)	Tramming 1 st Gear	0:56:56	0.28	0.24	0.76	0.76	6.7	4.7	12.7	12.7	Vertical	2:06	>12	Moderate
Extra Wear Package	Tramming 2 nd Gear	0:22:10	0.76	0.7	0.59	0.76	10.4	9.4	7.8	10.4	Fore-Aft	3:30	11:24	Moderate
OEM (No package)	Tramming 2 nd Gear	1:24:36	0.43	0.37	1.3	1.3	9.6	7.5	21.6	21.6	Vertical	0:18	6:18	High
Extra Wear Package	Dozer Push	0:17:00	0.85	0.95	0.85	0.95	17.2	19.2	15.5	19.2	Side-to-Side	2:12	>12	Moderate
OEM (No package)	Dozer Push	0:36:02	0.59	0.48	0.85	0.85	11.7	9.3	15.4	15.4	Vertical	1:00	>12	Moderate
Extra Wear Package	Dozer Ripping	0:15:04	0.79	0.89	0.74	0.89	16.2	18.7	14.1	18.7	Side-to-Side	2:30	>12	Moderate
OEM (No package)	Dozer Ripping	1:56:48	0.52	0.41	0.54	0.54	11.1	9.2	10.5	11.1	Fore-Aft & Vertical	3:36	>12	Moderate

- TRD530 was operated in similar Category 2 material for both assessments conducted
- Extra Wear Package causes more front/back (X-axis) and side-to-side (Y-axis) vibration exposure.
- OEM (No package) had a higher WBV exposure Risk Score and faster time to EAV/ELV, only for up/down (Z-axis).
- When comparing overall, OEM has *substantially lower* X-axis and Y-axis results in *all tasks*.
- Consideration for seat condition/setting is given for Z-axis and should be investigated further.

Evaluation method	EAV	ELV
a_{rms}	0.5 m/s ²	1.15 m/s ²
VDV (8)	9.1 m/s ^{1.75}	21 m/s ^{1.75}

Risk Criteria	Risk Score	Evaluation Criteria
More than 12 hours required to exceed both EAV/ELV	Low	$a_{rms} < 0.5$ VDV (8) < 9.1
EAV reached in less than 12 hours, but more than 8 hours required to reach ELV	Moderate	$0.5 < a_{rms} < 1.15$ $9.1 < VDV (8) < 21$
ELV reached in less than 8 hours	High	$a_{rms} > 1.15$ or VDV (8) > 21

Next Steps / Actions

- A comprehensive training package has been rolled out to address operational and ergonomic concerns specific to KSN series D11 dozers
 - Cabin ergonomics training,
 - Smooth/correct operation techniques, and
 - Proper use of KSN-specific features and controls.
- A blade swap trial was conducted on DZ25 and TRD530.
 - Results show a measurable improvement in ride quality and vibration characteristics.
 - Based on findings, BMA is considering:
 - Removing wear package material from KSN dozer blades or adding weight to the ripper box
 - Eliminating the corresponding line item from the TRD for KSN machines.
- Undercarriage maintenance will continue to be closely monitored to ensure:
 - Dozers leave the workshop with correctly adjusted or replaced components.
 - Checks include bogie stack heights, roller wear, idler height calibration, and track scalloping/pitch frequency effects.
- Operator feedback will be gathered post-maintenance and training to assess effectiveness.
- Site Safety and Health Representatives (SSHRs) have been informed of feedback, meeting minutes, and action items from all fortnightly reviews.
- All site work groups operating KSN D11 machines will be regularly updated on progress, outcomes, and any procedural changes resulting from ongoing investigations and trials



BMA



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