



A model noise declaration to satisfy the European Machinery and Outdoor Noise Directives

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ABSTRACT

A forestry woodchipper has been used to produce a model noise declaration according to the requirements of European Machinery Directive 2006/42/EC and Outdoor Noise Directive 2000/14/EC. Harmonised noise test code BS EN 13525:2005+A2:2009 was used to determine emission sound pressure level and peak sound pressure level. Withdrawn standards specified the Outdoor Noise Directive were used to determine the guaranteed sound power level. Testing to achieve meaningful and reliable noise emission values was difficult. The emission sound pressure test produced noise and peak noise higher than found when chipping logs or brush during normal use of the machine. The sound power tests to specified withdrawn standards were subject to greater uncertainty than those conducted according to their current equivalents. Emission sound pressure information was found likely to be useful to potential purchasers as a description of noise risk and for comparing the noise risk of competing machines.

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1. INTRODUCTION

The European Machinery Directive 2006/42/EC (1) requires that risks from work equipment are minimized through a hierarchy of: elimination or reduction by design and construction; protective measures for the risks that cannot be eliminated; and information for users about any risks that remain, including any particular need for training or personal protective equipment. The Directive sets out essential health and safety requirements (EHSRs) and includes EHSRs for noise.

The noise-specific EHSRs of the Machinery Directive are for minimization of noise risk, preferably at source, and reporting of noise emission in terms of emission sound pressure level, peak sound pressure level and sound power level. The general requirements of the Machinery Directive for elimination at source, reduction by protective measures and for information about residual risks and their management, apply to noise as they apply to other risks. For example, the noise data determined according to a noise test should represent noise risk; otherwise, alternative provision should be made for meeting the EHSR for reporting residual risk.

The Machinery Directive defers to the requirements of more specific European Directives where they exist. In the case of woodchippers, the Machinery Directive requirement for reporting the 'sound power level' is replaced by the requirement for reporting a 'guaranteed sound power level' under Outdoor Noise Directive 2000/14/EC (2). The woodchippers discussed here are one of 57 types of machine covered by the Outdoor Noise Directive.

A European Joint Action on market surveillance, NOMAD (3), found that 80% of the instructions for machines examined did not comply with the noise requirements of the Machinery Directive. The work described here is part of a wider project to improve the quality of noise information supplied with machinery to help employers to manage noise risk in their workplaces.

The noise of a forestry woodchipper has been used to produce a model noise declaration for use in the promotion of good practice reporting of noise information.

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2. NOISE INFORMATION REQUIRED FOR WOODCHIPPERS

2.1 General

The noise information required by the Machinery Directive is usually elaborated in harmonized standards. For woodchippers, safety requirements including noise requirements, are set out in standard BS EN 13525:2005 + A2:2009 (4), which references many other standards. This standard for woodchippers does not provide a presumption of conformity.

The method of measuring the sound power level is set out in annexes to the Outdoor Noise Directive and in withdrawn standards referenced in this Directive. The method of determining the guaranteed sound power level from the measured sound power level is not specified in the Directive.

The NOMAD project identified a need for improved guidance for manufacturers on how to report noise information compliant with the requirements of the Machinery Directive. A NOMAD guide for manufacturers (5) has been published setting out practical steps to provide noise information satisfying the requirements of the Machinery Directive and, where relevant, the Outdoor Noise Directive. The NOMAD guide complements the noise content of the Guide to the Machinery Directive (6).

2.2 Emission sound pressure level

The A-weighted emission sound pressure level at workstations must be quantified when it exceeds 70 dB(A). The emission sound pressure level takes account of the acoustic environment where the measurements are made such that an estimate of the noise level in other environments can be made. In the case of woodchippers – used outdoors over a hard surface – the correction is usually zero. The emission sound pressure level should be suitable for estimation of likely noise exposure and be useful as a guide to risk to hearing when controlling noise at work (7).

The workstation at a woodchipper is not fixed. The operator usually presents the material to the mechanical feed of the machine at the hopper and then stands to the side of the hopper once the material is feeding.

2.3 Peak sound pressure level

The peak C-weighted instantaneous sound pressure level must be reported when it exceeds 130 dB(C). The peak noise level should be a guide to risk of instantaneous hearing damage. The peak noise of woodchippers is erratic and may exceed the declaration threshold. The highest peak noise was observed when the fed material impacts the hopper.

2.4 Guaranteed sound power level

The Machinery Directive requires reporting of the sound power level when the emission sound pressure level at the workstation is more than 80 dB(A). However, the Outdoor Noise Directive applies for woodchippers (referred as shredders/ chippers) and the guaranteed sound power level is required whether or not the emission sound pressure level exceeds the threshold value set in the Machinery Directive.

The Outdoor Noise Directive requires the guaranteed sound power level to be marked on the machine and that the measured sound power level is reported in the accompanying declaration of conformity. The guaranteed sound power level is a level that takes account of the uncertainties due to production variation and measurement procedures and is not exceeded.

2.5 Need for particular training

If there is a method of operating woodchippers to minimize risk from noise, there is a need for particular training concerning noise for these machines. No such method is known.

2.6 Suitable hearing protection

Forestry woodchipper noise is usually extremely high and protection of the operators' hearing is highly dependent upon effective use of suitable personal hearing protection.

3. WOODCHIPPER NOISE EMISSIONS

3.1 Directivity

The noise emissions of forestry woodchippers can be more than 10dB higher in one direction than

in others. Figure 1 illustrates the directivity pattern found at the 20 microphone positions on the hemispherical measurement surface defined in BS EN ISO 3744:2010 (8). The highest noise is between the 6 and 7 o'clock positions aligned with the axis of the infeed hopper. Measurements are permitted with a 10 microphone array when there is low directivity but a 20 microphone array is required for the directivity found for this woodchipper.

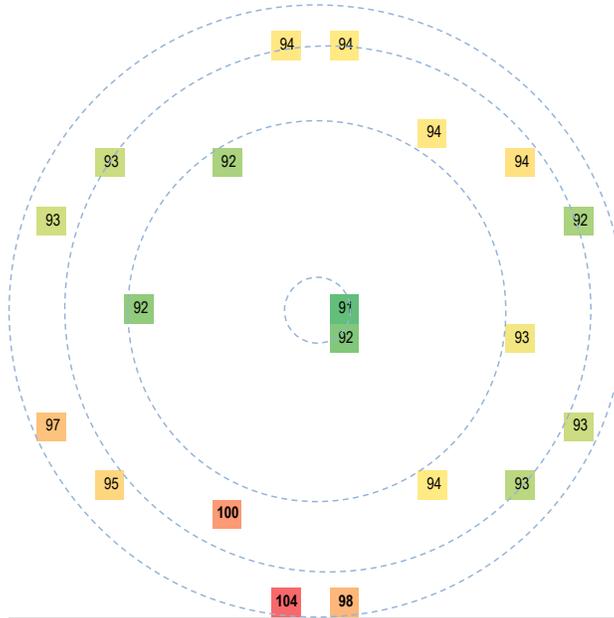


Figure 1 – Example noise levels measured over a hemispherical surface around a woodchipper

3.2 Emission sound pressure level

The emission sound pressure level was measured at a fixed position to represent a nominal operator position at the feed position in front of the hopper. The chipping cycle duration was shorter than the 10s specified in BS EN 13535 due to the machine feeding the specified test pieces in less than 10s. The achieved measurement durations of 5 to 9s appeared adequate for reliable measurements. The environmental correction for the measurements was 0dB. Measured values are summarized in Table 1.

Table 1 – Measured operator sound pressure levels over the chipping cycle L_{eq} dB(A)

	Lath	Log
	L_{Aeq} dB mean	L_{Aeq} dB mean and
Chipping cycle	and standard	Chipping cycle
durations s	deviation, (no. of	durations s
	measured cycles)	(no. of measured
		cycles)
	7 to 9	5 to 9
	112.5 ± 1.5 (8)	106.0 ± 1.0 (6)

When chipping logs, which are specified for sound power level testing in the Outdoor Noise Directive and representative of a common use of the machine, the emission sound pressure level was found to be about 106dB. When chipping laths, which are specified in BS EN 13535, the emission sound pressure level was 6 to 7dB higher at 112.5dB and had a larger standard deviation. Chipping brush, another common application of the machine, was found to produce lower noise than either of the specified test materials.

Brueck (9) found that the measurement uncertainty in emission sound pressure level was 4dB when chipping lath according to EN 13525:2009 + A2:2009 and 3dB when chipping logs as in the test specified in the Outdoor Noise Directive.

3.3 Peak sound pressure level

The peak sound pressure level was measured at the nominal operator position at the feed position in front of the hopper. The findings are summarized in Table 2. Normal operation of the machine chipping logs was found to produce peak levels close to but below the declaration threshold of 130dB(C). When chipping the lath specified in the safety standard and in the EC position paper on application of the Outdoor Noise Directive (10), the peak noise increased by more than 10dB.

Table 2 – Measured L_{pCpeak} at the nominal operator position

Lath		Log	
L_{pCpeak}	Highest and mean (number of chipping cycles) dB	L_{pCpeak}	Highest and mean (number of chipping cycles) dB
	140.5, 134.5 (8)		129.5, 129.0 (6)

Noise from chipping logs alone may not require a declaration of the peak noise. Chipping laths as specified in the safety standard and the EC position paper appears to be an adequate test for alerting purchasers to the risk from peak noise. The wide variation in peak noise from woodchippers when chipping long, thin strips of wood presents a problem in presentation of the peak value. Reporting the highest value obtained during the tests is sufficient to alert users to likely magnitudes of peak noise but the random nature of these peak events mean higher values could be measured during subsequent tests or during normal use.

It appears that normal use of the machine for the normal range in sizes of logs and branches will likely produce peak noise above the declaration threshold of 130 dB(C).

3.4 Measured sound power level

Sound power level was measured according to the current standard BS EN ISO 3744:2010. An array of 20 microphones was used in accordance with specifications concerning directivity of the woodchipper. The measurements were repeated with 4m and 6m radius microphone arrays to investigate the restriction to 4m and 10m arrays in the Outdoor Noise Directive. Tests were repeated using the pine logs specified in the Outdoor Noise Directive and the 4m x 50mm x 50mm pine laths specified in both the woodchipper safety standard and the EC position paper for forestry woodchippers.

It is clear from Table 3 that the sound power level of the woodchipper was higher by 5 to 6dB when chipping the test lath than when chipping logs.

Table 3 – Measured emission L_{wA} using BS EN ISO 3744:2010 array

Lath			Log		
L_{wA} to position paper dB(A)	L_{wA} mean and standard deviation dB(A)	Number of cycles	L_{wA} to Outdoor Noise Directive dB(A)	L_{wA} mean and standard deviation dB(A)	Number of cycles
121.5	121.0 ±1.5	8	116.0	115.5 ±1.0	6

The Outdoor Noise Directive specifies use of a withdrawn ISO standard, ISO 3744:1995 (an earlier version of (8)) and requires a 6 microphone array. There is no guidance on the orientation of directional sound sources within the 6 microphone array. Tests were repeated with various orientations of the woodchipper within the 6 microphone array to investigate how machine orientation affected the measured sound power level. The range of estimated sound power levels when chipping lath and when chipping logs are reported in Table 4. The estimated sound power level can vary by up to 6dB depending on the orientation of the woodchipper within the array. These data also show that chipping laths produces sound power levels 5 to 6 dB above those measured when chipping logs.

Table 4 – Estimated L_{WA} using a 6 microphone array

Laths to Position Paper dB(A)			Logs to Directive dB(A)		
Lower value	Upper value	Difference	Lower value	Upper value	Difference
118.5	124.5	6.0	113.5	118.5	5.0

Brueck (9) found the uncertainty associated with the sound power level was 4dB when chipping lath according to the EC position paper (based on BS EN 13525:2005 + A2:2009) and 3dB when chipping logs according to the Outdoor Noise Directive.

3.5 Guaranteed sound power level

The Outdoor Noise Directive permits any established method of determining the uncertainty in the measured sound power level, such that a guaranteed sound power level can be determined. The guaranteed sound power level is the value provided for the machine purchaser. This is the measured weighted sound power level L_{WA} plus K_{WA} which is the uncertainty of this measurement in decibels.

The method of determining the guaranteed sound power chosen for these tests is that given in BS EN ISO 4871 (11). For a single machine, this standard defines K as the standard deviation of reproducibility multiplied by 1.645. The 1.645 weighting yields a 95% certainty for the guaranteed sound power level not being exceeded. Values of the standard deviation of reproducibility are normally found in the noise test code. If no noise test code exists, an estimated value of K which may be used for the sound power level is 2.5 dB for engineering grade accuracy (grade 2) measurements.

The Outdoor Noise Directive does not specify the ‘coverage factor’ (or confidence interval required) for the guaranteed sound power level and it does not require it to be reported. The manufacturer is required by the Outdoor Noise Directive to have this information available for inspection by the national authority but there does not appear to be any requirement to make it available to purchasers. The purchaser is supplied with the guaranteed sound power level upon purchase of the machine and should have access to the measured sound power level in the declaration of conformity that accompanies the machine.

4. PLANNING FOR USE OF A WOODCHIPPER WITHOUT RISK FROM NOISE

4.1 Noise hazard and noise risk

A purchaser of work equipment in Europe should be able to use information supplied with the equipment to plan measures for its safe use. In the case of noise, it might be expected that the noise emission data reported to a harmonized standard will describe noise hazard. But this is not always the case and other methods of reporting noise hazard may be required. The test method specified in BS EN 13525:2005 + A2:2009 has been found to produce noise emission data that clearly identifies a noise hazard and a peak noise hazard from woodchippers. The noise determined using the standard test is higher than is found during many normal uses of a woodchipper.

In Europe, noise risk should be assessed and managed by employers according to Physical Agents (Noise) Directive 2003/10/EC (7). Peak noise risk is assessed directly from the magnitude of the peak noise. Risk from continual noise is determined from noise exposure – a combination of how loud and how long a worker is exposed.

4.2 Risk from noise exposure of woodchipper operators

An employer using the emission sound pressure level shown in Table 1 in combination with estimates of exposure duration, appears likely to estimate noise exposure of the operator in the top part of the likely range. There is unlikely to be any need to modify the emission sound pressure level to take account of the acoustic environment because woodchippers are usually used outdoors in an acoustical environment similar to that specified for the test.

For the woodchipper data shown in Table 1, the employer must manage exposure to noise at levels between about 106dB and 113dB.

Limiting exposure duration is not a reliable control measure because the Upper Exposure Action value defined in Directive 2003/10/EC would be exceeded in less than one minute at 113dB. Control of risk from noise during woodchipping is almost certainly dependent upon the operators’ effective use of hearing protection. The instructions for work equipment should contain guidance on selection of

suitable personal protective equipment – hearing protection. Hearing protection is required for the operator that will reduce the L_{pA} at the ear to below 87 dB and preferably to between 75 to 80 dB during normal working operations. It may be necessary to use a combination of earplugs and earmuffs to obtain adequate protection if normal work is similar to chipping laths.

4.3 Risk from peak noise for woodchipper operators

An employer using the peak sound pressure level determined for the woodchipper processing laths according to BS EN 13525:2005 + A2:2009, may over-estimate peak noise for operators chipping logs or brush. It has not been determined from these tests if chipping of long thin branches or other feed results in peak noise similar to that determined for laths.

In practice, hearing protectors that provide sufficient protection against continuous sound pressure levels are likely to provide adequate protection against all measured peak sound pressure levels.

4.4 Sound power level and noise risk

Neither the measured nor the guaranteed sound power level has a role in determining noise risk.

4.5 Determining likely noise risk

Noise risk is best described by the emission sound pressure level. The peak sound pressure level provides a guide to the likely presence of risk from peak noise. Testing with laths is the noisiest operation observed for the machine tested but how this compares with normal uses of the machine should be investigated further.

5. COMPARING THE NOISE OF COMPETING WOODCHIPPERS

5.1 Comparisons using emission sound pressure level

The emission sound pressure level of woodchippers is well described for the chipping of lath in the test code within BS EN 13525:2005 + A2:2009. This may be representative of chipping material such as long thin branches, which may thrash about hitting the feed hopper during feed.

Chipping the logs specified in the Outdoor Noise Directive test for sound power level, produces values of emission sound pressure level that are about 6dB lower than those measured when chipping laths.

The uncertainty defining the 95% confidence interval in the emission sound pressure level is 3dB when chipping logs and 4dB when chipping laths.

The emission sound pressure level appears to be a useful measure to use when comparing the noise emission of woodchippers.

5.2 Comparisons using peak sound pressure level

Reporting of peak sound pressure level is a method of alerting purchasers of the need to manage risk of instantaneous hearing damage from peak noise. Purchasers of work equipment should be seeking equipment where peak noise does not exceed the declaration threshold of 130dB(C).

Peak noise from the woodchipper tested barely reached the declaration threshold when chipping logs. Testing with laths clearly exceeded the declaration threshold and may be representative of normal operations likely to produce high levels of peak noise.

The erratic nature of peak noise from woodchippers and the absence of a specification for reporting peak sound pressure levels make it likely that reported values will be unsuitable for comparisons but should be suitable for warning the purchaser of likely presence of risk from peak noise.

5.3 Comparisons using measured sound power level

The guaranteed sound power level should be marked on the machine but a purchaser may not see the measured sound power level prior to purchase. The measured sound power level should appear in the declaration of conformity supplied with the machine. It may also be found on the Outdoor Noise Directive database (12) where the European Commission reports noise emissions for machines in scope of the Outdoor Noise Directive.

The preference for a 6 microphone array and the absence of a specification of an orientation of the woodchipper within this array is shown to result in variations up to 6dB in the measured sound power level. This is the same whether chipping logs as specified in the Outdoor Noise Directive or chipping laths as specified in an EC position paper.

The uncertainty defining the 95% confidence interval for measured sound power level was found by Brueck (9) to be 3dB when chipping logs and 4dB when chipping laths.

The measured sound power level appears to be limited in its suitability for comparing the noise emission of woodchippers because of weaknesses in the specification of the test, which can affect the measured sound power level by up to 6dB.

5.4 Comparisons using guaranteed sound power level

The guaranteed sound power level should be marked on the machine and should be available from the Outdoor Noise Directive database (12).

The method of determining the guaranteed sound power level from the measured data is not defined in the Outdoor Noise Directive and information on the method used is not necessarily available to a purchaser. The measured sound power level, from which the guaranteed value is determined, has already been shown to be limited because the noise test does not adequately control for the directional noise of woodchippers.

The guaranteed sound power level appears unreliable as a measure to use when comparing the noise emission of woodchippers because of weaknesses in the specification of the test and weaknesses in the specification of determining the guaranteed sound power level from the measured data.

5.5 Comparing noise from woodchippers

The emission sound pressure level currently provides the most reliable method of reporting and comparing the risks from noise of competing woodchippers.

Sound power level information is less reliable and more difficult to obtain than emission sound pressure level at the workstation. Guaranteed sound power levels appear likely to be less reliable than measured sound power levels for comparing machines because guaranteed values are likely to have been determined by different methods.

Woodchipper sound power levels are not currently subject to limits. Observation of the Outdoor Noise Directive database suggests that the presence of a limit may further reduce the value of the sound power level as a means of comparing the noise emissions of competing machines. The database shows that many machines are declared at or only slightly below the limit, even when reported measured values are far below the limit.

6. A MODEL NOISE DECLARATION FOR A WOODCHIPPER

6.1 Example entry in woodchipper instructions

Figure 2 contains a sample noise declaration for woodchippers that includes information to help the user assess and manage the noise risk associated with using woodchippers. The data provided includes emission sound pressure levels, peak sound pressure levels and sound power levels derived in accordance with the requirements of the Machinery Directive and the Outdoor Noise Directive.

6.2 Simplification of entries for noise in woodchipper instructions

The report above is made to satisfy the requirements of the Machinery Directive. Sufficient information describing and facilitating comparison of noise risk is provided by the emission sound pressure level and peak sound pressure level. A sound power level measurement is needed to meet the requirements of both the Outdoor Noise Directive and the Machinery Directive.

<p>Operator sound pressure levels at the infeed hopper</p> <p>This wood chipper produces sound levels that put the operator’s hearing at risk. The tables below give the noise emission values obtained according to requirements of the Machinery Directive.</p>	
<p>DECLARED DUAL-NUMBER NOISE EMISSION VALUES</p> <p>in accordance with ISO 4871</p>	
Measured A-weighted emission sound pressure level, L_{pA} (ref. 20 μ Pa) at the operator’s position at the infeed hopper, in decibels	113
Uncertainty K_{pA} , in decibels	4
Measured C-weighted peak emission sound pressure level, L_{pCpeak} (ref. 20 μ Pa) at the operator’s position, in decibels	141
<p>The numerical values reported here are measured according to the noise test code given in BS EN 13525:2005 + A2:2009, using the basic standard BS EN ISO 11201:2010. During these emission tests the woodchipper was chipping pine laths.</p>	
<p>NOTES:</p> <p>The standard operating condition (chipping 4m x 50mm x 50mm pine laths) provide emission L_{pA} values that are particularly noisy. A common operating condition is when chipping pine logs; under these conditions:</p> <ul style="list-style-type: none"> • The measured A-weighted emission sound pressure level L_{pA} is 106 dB re 20μPa with uncertainty K_{pA} of 3 dB. • The measured C-weighted peak emission sound pressure level L_{pCpeak} is 130 dB re 20μPa. 	
<p>Sound power level of the woodchipper</p> <p>The sound power is a measure of how much noise a machine produces rather than how loud it is at any position. It can be used to compare the noise emission of different machines. The table below gives the guaranteed sound power level obtained in accordance with the Outdoor Equipment Directive.</p>	
<p>Noise declaration in accordance with the Outdoor Noise Directive</p>	
Measured A-weighted sound power level L_{WA} (dB re 1 pW)	116
Guaranteed A-weighted sound power level (95% certainty) L_{WA} (dB re 1 pW)	119
<p>NOTES:</p> <p>The operating conditions were chipping single pine logs in accordance with the chipper/ shredder noise test code in Annex III, Part B of the Outdoor Equipment Directive as amended by M1 (2005) and C1 (2006).</p>	
<p>Controlling the noise risk for the operator</p> <p>The emission sound pressure levels at the operator’s ear during the operation of this woodchipper may reach 113 dB(A). It is likely that operator noise exposures will exceed the upper action values defined in Directive 2003/10/EC during normal use of this machine. Hearing protection is required for the operator that will reduce the L_{pA} at the ear to below 87 dB and preferably to between 75 to 80 dB during normal working operations. It may be necessary to use a combination of earplugs and earmuffs to obtain adequate protection. Hearing protectors that provide sufficient protection against these high continuous emission sound pressure levels are likely to provide adequate protection against the declared peak sound pressure levels.</p> <p>The noisiest location during chipping is in front of the infeed hopper. The operator can reduce their noise exposure by moving away from the front of the hopper once it is filled.</p>	

Figure 2 – Sample noise declaration for woodchippers

7. CONCLUSIONS

Preparing an example noise declaration for a woodchipper was much more complicated than expected because of confusing and contradictory information in the Directives, standards, etc.

Manufacturers must correctly choose from three different noise measurement specifications and from two different machine operating conditions, each producing different results. The manufacturer has a free choice of method to determine the guaranteed sound power level from the measured sound power level.

The noise test code for woodchippers in BS EN 13525 makes clear the presence of noise risk when operating these machines, in terms of both emission sound pressure level and peak sound pressure level. The reported noise risk is about 6dB higher when chipping specified pine laths than when chipping logs.

The degree to which chipping of pine laths represents the noise produced by woodchippers during normal use should be investigated further.

The measured sound power level is subject to uncertainty because the orientation of the woodchipper within the 6 microphone array is not specified in the test method. The uncertainty reduces when using a 20 microphone array according to current versions of the basic acoustic standards referenced in the Outdoor Noise Directive.

The guaranteed sound power levels supplied with competing woodchippers may not be comparable due to differences in approach chosen by each manufacturer to determine the uncertainties due to production variations and measurement methods.

The emission sound pressure level provides both a guide to noise risk and a means of comparing the workplace noise risk of competing machines. The findings here suggest that comparisons using emission sound pressure level are capable of reliably identifying smaller differences between machines than can be achieved with the sound power level.

Emission sound pressure level is a simple, one microphone measurement that produces useful numerical values to help plan use of work equipment without risk from noise.

Sound power level requires an array of between 6 and 20 microphones on a hemisphere of at least 4m radius and facilitates the comparison of environmental noise of competing machines.

The noise testing required for woodchippers could and should be simplified to provide improved a) identification of the likely noise risk and b) comparison of the noise of competing machines.

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DISCLAIMER

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