No. 3684-P-00

SAFETY PROMOTION NOTICE

SUBJECT: GENERAL

Noise & downwash considerations for ground operators

For the attention of	

AIRCRAFT CONCERNED	Version(s)	
	Civil	Military
EC120	B	
AS350	B, BA, BB, B1, B2, B3, D	L1
AS550		A2, C2, C3, U2
AS355	E, F, F1, F2, N, NP	
AS555		AF, AN, SN, UF, UN, AP
EC130	B4, T2	
SA365 / AS365	C1, C2, C3, N, N1, N2, N3	F, Fs, Fi, K, K2
AS565		MA, MB, SA, SB, UB, MBe
SA366		GA
EC155	B, B1	
SA330	J	Ba, L, Jm, S1, Sm
SA341	G	B, C, D, E, F, H
SA342	J	L, L1, M, M1, Ma
ALOUETTE II	313B, 3130, 318B, 318C, 3180	
ALOUETTE III	316B, 316C, 3160, 319B	
LAMA	315B	
EC225	LP	
EC725		AP
AS332	C, C1, L, L1, L2	B, B1, F1, M, M1
AS532		A2, U2, AC, AL, SC, UE, UL
EC175	B	
H160	B	
EC339		KUH/Surion
BO105	C (C23, CB, CB-4, CB-5), D (DB, DBS, DB-4, DBS-4, DBS-5), S (CS, CBS, CBS-4, CBS-5), LS A-3	CBS-5 KLH, E-4
MBB-BK117	A-1, A-3, A-4, B-1, B-2, C-1, C-2, C-2e, D-2, D-2m, D-3, D-3m	D-2m, D-3m
EC135	T1, T2, T2+, T3, P1, P2, P2+, P3, EC635 T1, EC635 T2+, EC635 T3, EC635 P2+, EC635 P3, T3H, P3H, EC635 T3H, EC635 P3H	

Introduction

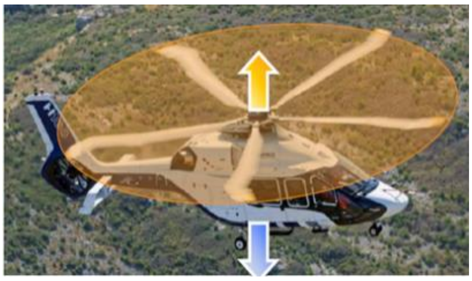
Airbus Helicopters wants to provide its operators with information on the effects of downwash on the ground, to enable them to make a good infrastructure design and establish suitable ground operating procedures.

The airspeed values given below are taken from simplified models, which may not account for local variations. Make use of these values accordingly.

Complementary information about helicopter noise is also provided.

Basic principle of rotor operation

The principal functions of the main rotor are to provide lift, propulsion, and control of the helicopter. The force created by the helicopter is generated by the blades, which create this lift by rotating through the air.



In hovering flight, a balance is created between the lift and the weight of the aircraft, allowing it to be suspended.

The propulsion and control of the helicopter are achieved by tilting the rotor to orient this force in different directions: forward to move forward and to the side for lateral flight or, in some cases, to balance the aircraft.

Many parameters are considered in the design of the rotor: the diameter of the rotor, the number of blades, the shape of the blades (straight or double-swept), airfoil shape, etc.

Hover Out of Ground Effect (HOGE)

In HOGE, Froude's theory creates a connection between air speed at the rotor level squared and two parameters.

The two main parameters are the mass of the aircraft and the disc area. **The speed therefore depends directly on the mass and the rotor diameter**: the heavier the helicopter, the higher the downwash speed; the larger the disc area, the lower the speed. The two are actually related, and the relationship is referred to as **disc loading**: the mass / area. This load will vary between different helicopters, but not by much. Finally, Froude's relation also indicates that the induced velocities depend on the temperature, altitude and/or pressure conditions via the air density.

	AS350B3	H135	H145 T2	EC155B1	H160	EC225
$V_i\ [m/s]$	10	12	12.5	12.5	13	15
$V_{max}\ [m/s]$	20.5	24	25	25	26	30
$\mathbf{V_{max}\ [km/h]}$	**74**	**86**	**90**	**90**	**94**	**108**

Mass x5, but V_i x1.5 !

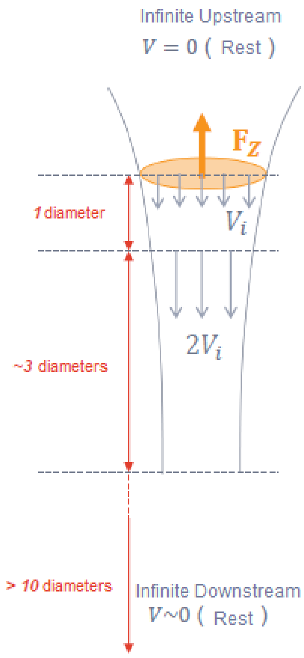
$$V_i = \sqrt{\frac{M\,g}{2\,\rho\,S}}$$

Aircraft Mass

Rotor Disc Surface

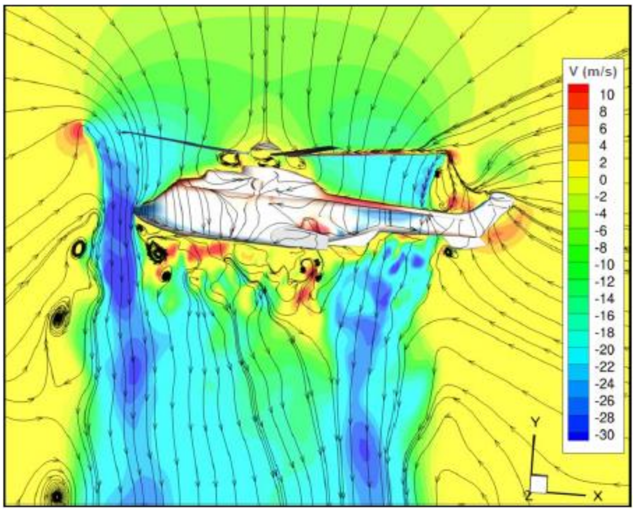
	AS350B3	H135	H145 T2	EC155B1	H160	EC225
Main rotor diameter (m)	10.69	10.4	10.8	12.6	13.4	16.2

As an example, the variation in mass (MTOW) between an Ecureuil and an EC225 is quite significant: approximately 2,250 kg to 11,160 kg respectively. However, the airspeed factor is 1.5, while that of the mass is 5. **We can see that the disc loading varies a bit. Indeed, the heavier the aircraft, the larger the rotor disc usually is.**



This diagram shows the evolution of theoretical speeds near the disc based on conservation of mass and momentum. An airflow goes through the disc. A contraction is produced in the tube, which accelerates the airflow for approximately 1 diameter of the disc.
The induced velocity, which was evaluated by Froude's relation, is equal to twice the airspeed near the disc: 2Vi.
This airspeed remains more or less constant up to 3 disc diameters.
Beyond this distance, turbulence will dissipate the flow little-by-little, which will cause the induced velocity to gradually tend towards 0; **10 diameters should be enough to bring the air to rest.**

In practice, there are slight differences. **The distribution of the induced velocity on the disc is not uniform.** The speed is more concentrated on the ends of the blade. This concentration causes the velocity to be higher than the average induced velocity. Also, the downwash interacts with the fuselage, which might create more local acceleration. At the level of the disc, the airspeed is 20 m/s in this example.
In addition, the airflow is unsteady, and we will find structures that will appear and change over time, such as **blade tip vortices. This phenomenon is directly related to the hover effect of the rotor disc**.



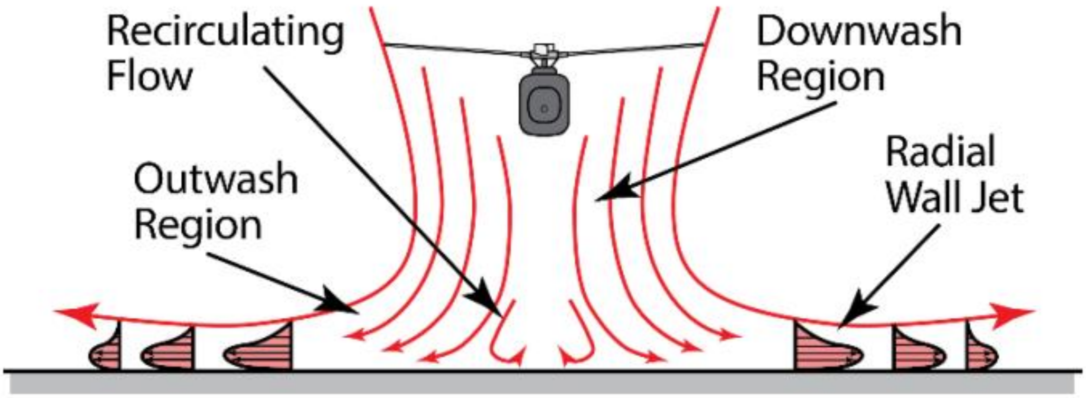
With regards to these airspeeds, here are some notable orders of magnitude for windspeed:
- 60 km/h: small pebbles (< 1 cm or a half inch) can be projected with low energy by the airflow. Limited damages may occur.
- 80-90 km/h: stones (> 1 cm or a half inch) and roof tiles may be projected with more significant damages.
- 100 km/h: it is difficult for an adult to walk against the wind at that speed.
- 130 km/h: it is difficult to stand upright. A 60 kg adult may be knocked over.

Hover In Ground Effect (HIGE)

As the helicopter approaches the ground, the behavior of the downwash will be significantly modified by the effect of the ground.
We find the same downwash region at the beginning. Then there is a change in the direction of the airflow:

- Some downwash is sent to the side, in all directions: this is the **outwash region**. It goes in all directions (n) coming off the axis of the aircraft.
- Part of the downwash remains stuck inside: This is the **recirculating flow**.

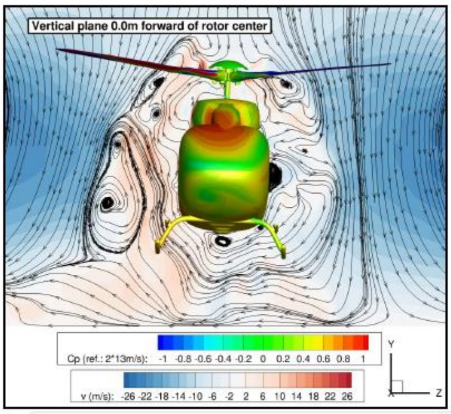
Once the airflow changes direction, the speed changes. The Preston model gives this maximum speed at a given station as a function of this distance.



Ref.: [Experimental Investigation of Rotorcraft Outwash in Ground Effect]

Preston's model explains that speed changes with the inverse of distance: The further away from this point, the lower the speed (1/d).
For an EC225, for example, which is flying at 1 diameter from the ground, namely at 16 m, we find the maximum speed calculated with Froude's theory (110 km/h).

In reality, it is not that simple; when a helicopter is hovering, the rotor disc is not usually perfectly horizontal. The symmetry of the axis in the diagram is not found in reality.
In order for the aircraft to hover, the rotor must be tilted slightly due to the forces exerted on the helicopter. We do find this airflow behavior that impacts the ground and goes into the outwash region, but this behavior is not axis-symmetrical. The airflow is no longer the same on the left and on the right. **There may be recirculation flow near the aircraft because of the interactions.**



Ground operation, taxiing and lateral flight

Ground operation: On the ground, the rotor disc turns at low pitch (collective). So even if the blades are rotating in the air, they create very little lift and therefore very little airflow. **The air speed around the helicopter is usually around 20 km/h.**

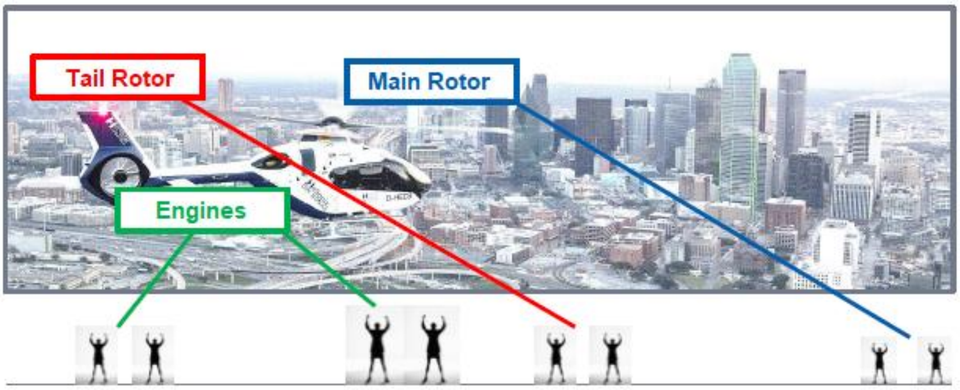
Taxiing: To move the helicopter forward during the taxiing phase, some lift must be created. The disc still turns at low pitch but not at minimum speed. **The airspeed around the helicopter usually varies between 15 km/h and 35 km/h, depending on the class of helicopter**

Lateral flight: The behavior of the downwash in lateral flight is similar to hovering. The difference is that the airflow will no longer be axis-symmetrical, but rather on the side of the helicopter: it is said to be non-axisymmetric. Typical air speed around the helicopter is equivalent to induced velocities from Froude and Preston models, which usually vary between 170 km/h and 120 km/h, for the examples in this SPN.

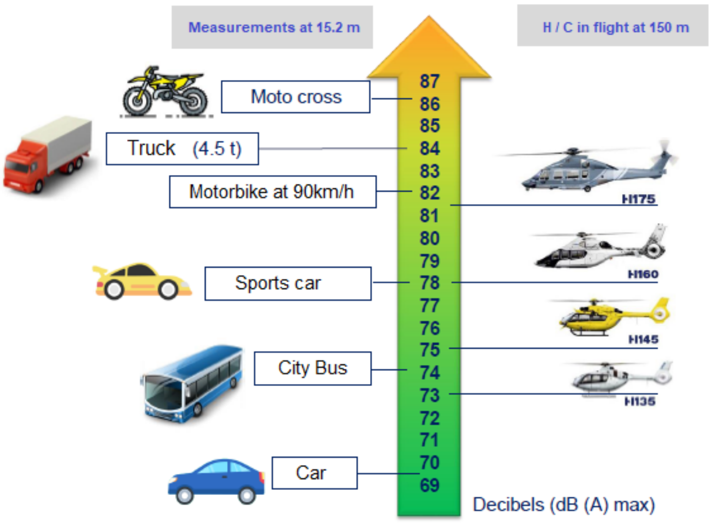
Acoustic

There are several sources of noise on a helicopter: predominantly the Main Rotor, the Tail Rotor, and the Engines. The Main Gearbox, which is a significant contributor inside the H/C, only yields a limited contribution in the vicinity of the helicopter.

The relative contribution of these 3 sources on the perceived noise on the ground significantly depends on the H/C type (weight, Fenestron or conventional tail rotor, installed noise control technologies), the flight condition (fly-over, climb, descent, hovering or ground operations), and the relative position of the observer.



Noise scale



The noise scale (in decibels) puts the noise of a helicopter into perspective.
Due to the complex behavior of the human ear, we do not perceive all frequencies in the same way. The noise levels here are shown in dB(A), which is the traditional unit used to consider actual perception of noise.

The noise levels of our level helicopters flying over at a distance of 150 m are lower than a motorcycle riding at 90 km/h at a distance of 15.2 m.

Noise in flight

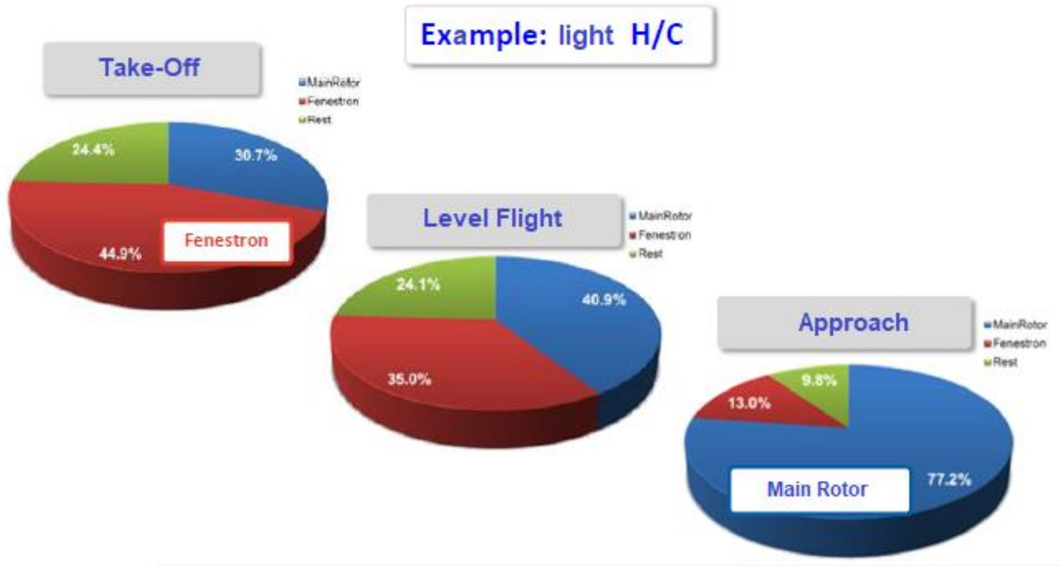
As mentioned above, noise source contribution depends on flight condition.

Take-off & climb phase: During the take-off & climb phase of the helicopter, the main rotor is required to provide a maximum thrust level to gain altitude quickly. This results in high anti-torque and engine power requirements. Depending on the technology (traditional or Fenestron), the Tail Rotor can be the dominant noise source in this flight condition due to the high thrust it has to provide. Also, the engine noise emitted through the exhaust pipes can have a noticeable contribution in this flight state, especially for an observer positioned behind the helicopter.

In the level cruise flight phase, the power requirement is generally lower than for take-off, and the anti-torque system is augmented by the vertical fin, resulting in only relatively small thrust levels. An important in-cruise condition is the high forward speed that adds to the rotational speed of the rotor, thus yielding high velocities on the advancing blade tips of the main rotor and tail rotor. The 2 main contributors are the Main Rotor and Tail Rotor. Fenestron-equipped helicopters yield significantly lower noise levels.

Approach phase: This phase is generally the loudest flight condition for helicopters, despite lower power requirements. The special phenomenon called blade-vortex interaction (BVI) is responsible for the very characteristic “blade slap” noise emitted by the main rotor, which is clearly the main noise source.

An example of noise source contribution in these 3 flight phases is shown below for a light h/c with a Fenestron. Obviously, these pie charts may vary depending on the H/C.



Ground and Hover operations

Ground operations can be sensitive operations in terms of noise impacts for people on the ground (passengers, crew, workers) since **they are located near** the helicopter. Despite the very low power requirement, the noise level can reach 110-120 dB(A) close to the Helicopter. The main sources of noise are then the engines and, to a lesser extent, the rotors.

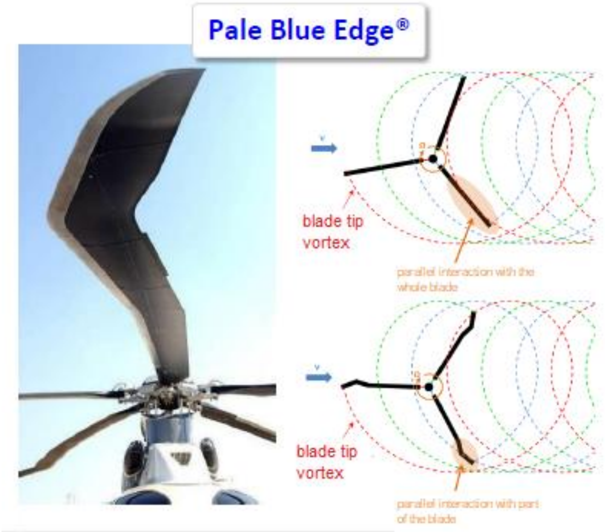
The duration of ground operations shall be minimized when possible, and **Airbus Helicopters recommends that people around the helicopter wear hearing protection**.

Hovering yields similar consequences, but to a lesser extent since the helicopter does not generally stay as long as on the ground and the distances between sources and receivers tend to increase.

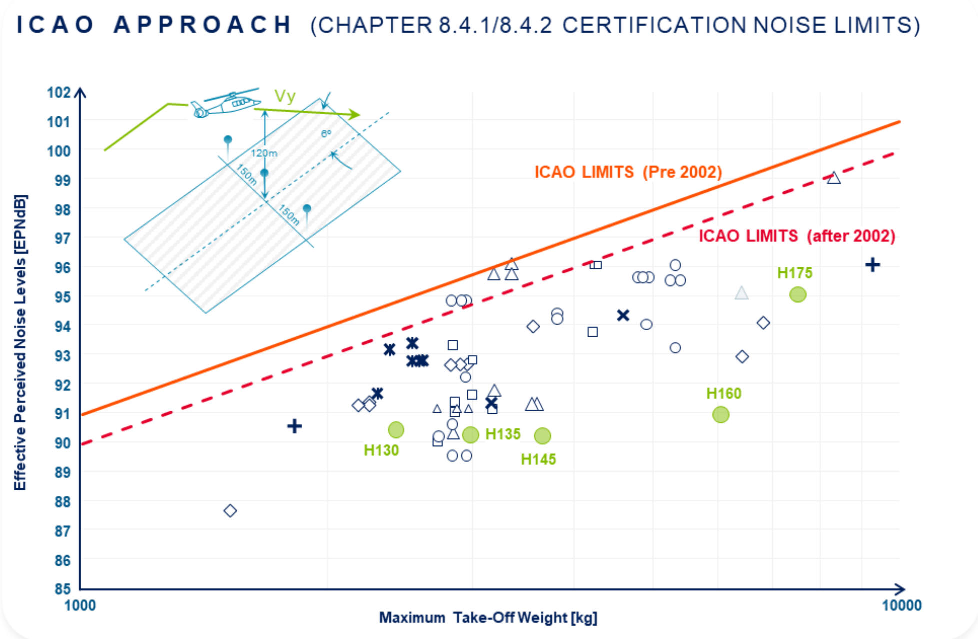
These 2 operating conditions are not governed by noise certification levels, but the operator shall ensure Health and Safety regulations for workers that generally (depending on the country) impose maximum noise exposure levels on daily (8-hour) periods (example ED2003/10/CE).

Noise reduction:

Airbus Helicopters regularly embeds new technologies to reduce noise on its products, such as the silent Fenestron® shrouded tail rotor, new blade shapes, and an automatic variable rotor speed control system. As an example, the latest H160 integrates all these technologies, with the latest Blue Edge® double-swept blade specifically and successfully designed to reduce BVI noise, reducing parallel interactions between blades and tip vortices.



With these advanced technologies, the Airbus Helicopters fleet is consequently very well positioned on noise levels compared to the competition. An extract of these public databases for noise certification (see https://www.easa.europa.eu/domains/environment/easa-certification-noise-levels) is shown for the approach flight condition below.



Innovation efforts are ongoing to further reduce, for example, Fenestron® noise and engine noise (e.g., for ground operations, despite no specific requirements existing) or to propose low-noise operating procedures to customers.