AIRPLANE PERFORMANCES

1. Introduction

In function of their category of approach, aircraft are not sharing the same characteristics.

The main points of difference will be found at:

- Maximum Operation Speed
- Approach Speed
- Minimum Clean Speed
- Final Approach Speed
- Minimum Approach Speed
- Rate of Climb/Descent

2. The maximum operation speed (V_{MO})

V_{MO} or maximum operation speed is the air speed than should never be exceeded deliberately in normal operation, whatever the flight situation is.

When flying at V_{MO} the aircraft may reach its maximum descent rate.
The maximum operation speed can be exceeded during flight tests. This is used to define safety margins and assess a V_{MO} which can be safely exceeded accidentally.

When the VMO is exceeded the aircraft can be damaged:

- Excessive mechanical constraints on the aircraft structure leading to permanent deformations
- Excessive mechanical constraints on the engine air inlets
- Deformation of bearing structures
- Shock waves leading to shakes, loss of bearing capacity and bad manoeuvrability
- Unusual heating

Together with the V_{MO}, other characteristic speeds are defined for some airplanes:

- V_{NO}: Normal Operating speed
- V_{NE}: Never Exceed speed

In some anemometers the V_{NE} is indicated with a red line.
In some anemometers the speed range above V_{NO} and below V_{MO} is indicated with a yellow arc.

The V_{NO} should never be exceeded in case of wind gusts since the V_{NE} could be reached and exceeded in this situation. V_{NE} or never exceed speed shall not be exceeded at any time during the life of an aircraft. Above this speed the aircraft will be damaged.

3. Speed reduction and regulation

3.1. Normal reduction

When the controller asks for a speed reduction without any further precision, the pilot shall simply reduce thrust to decelerate and reach the cleared speed.

The speed reduction can be rather long: a reduction from 320 to 220 KIAS requires 10 NM at 10000 ft and 7 NM at 5000 ft.

3.2. Fast reduction

If the controller asks for a fast reduction, the pilot shall reduce thrust and extract speed brakes and spoilers.

Spoilers and speed brakes are secondary flight control surfaces that can be deployed manually by the pilot or, under certain circumstances, extend automatically. Speed brakes are purely drag devices while spoilers simultaneously increase drag and reduce lift.

Once the cleared speed is reached he can retract the spoilers and adjust the thrust to maintain this speed.

A speed reduction is rather incompatible with a descent. When a speed reduction is cleared, most pilots stop their descent or set a low descent rate until the required speed is reached.

The controller shall make a choice between:

- ask the pilot to reduce speed and then perform a descent at reduced speed
- ask the pilot to descend and then proceed with the speed reduction

3.3. Speed regulation

The speed indicated on the anemometer is the **IAS** (Indicated Air Speed).
This speed is different from what is displayed on the ATC radar which is the **GS** (Ground Speed), equal to the **TAS** (True Air Speed) corrected by the wind drift.

When flying at constant IAS, air traffic controllers shall be aware that TAS or GS will increase when the altitude increases or decrease when the altitude decreases.

It is completely useless for a controller to use the IAS as a regulation means when the aircraft are separated by more than 4000 ft.
For a given IAS and a given flight level, the TAS varies only little within a range of ± 2000ft around this level, but TAS can have significant difference when the altitude difference is more than 4000ft even if both aircraft will use the same IAS.

Then, a controller will use a speed regulation in order to maintain current regulation when the altitudes between all aircraft in the sequence are comparible.

4. Approach speed

The approach speed can be limited to 250KIAS maximum in function of the airspace class.

4.1. The 220 KIAS speed

The typical speed used to regulate traffic in approach control is 220 KIAS (IAS expressed in kt) since most aircraft (except General Aviation) can safely maintain it.

The main advantages of this 220KIAS speed are:

- For most aircraft the minimum clean speed (flaps and slats retracted) is lower than or equal to 220 KIAS
- This is the maximum allowed speed of holding circuits below FL140
- The aircraft can easily accelerate if needed since flaps and slats are still retracted
- The aircraft can easily decelerate since most of the times flaps and slats can be extracted immediately without waiting to reach a lower speed.

Keep in mind that most pilots do not like to proceed to an early flap extraction since this badly affects the fuel consumption (except some heavy liners with a minimum flaps retracted speed ranges between 230 and 250 KIAS.

4.2. The minimum clean speed

Below 220 KIAS the controller may safely ask the pilot to reduce to minimum clean speed. This is the minimum operating speed with flaps and gear retracted.

The use of this speed can be useful for the controller in case a deceleration is needed since it does not affect the fuel consumption which increases significantly when flaps are extracted.

The minimum clean speed can be quite different from one airplane to another.
Be aware that some of the “**Heavy**” wake turbulence category aircraft have a minimum clean speed higher than 220 KIAS.
In IVAO, many pilots do not know their minimum clean speed.

4.3. High speed on final

Depending on the aircraft, the final approach speed ranges between 110 and 170 KIAS (except General Aviation airplanes).

If the controller wants an aircraft to maintain a high approach speed on final he can ask for a speed of 180 KIAS maximum until the OM (Outer Marker) or the FAF/FAP.

Beyond the FAF/FAP or the OM the controller cannot impose a speed restriction and shall negotiate it with the pilot who is the only responsible of his final approach speed.

The pilot may refuse to begin the approach procedure at too high speed.

4.4. The minimum approach speed

Whenever the controller needs to ensure traffic separation on final, he may impose to reduce to the minimum approach speed (minimum speed with flaps and gear fully extended).

It is advised not to impose such a speed restriction before 15 NM from the airfield since it would oblige the aircraft to fly a rather large distance in a configuration close to the stall speed. Moreover, this configuration leads to a significant increase of the fuel consumption.

Be careful in using this speed when regulating the approach flow since for some airplanes the minimum approach speed is very low (less than 80 kt).

An aircraft with a speed of 80/100 KIAS at 10 NM from the airport may spoil the regulation flow.

5. Bank angle

The normal bank angle ranges between 25° and 30° (clean configuration). A bank angle exceeding 30° is considered as uncomfortable for passengers.

During a holding circuit at the minimum clean speed or at the published maximum hold speed the bank angle shall not be less than 25°. The bank angle is reduced to 15° when flaps are extracted. This is due to the fact that in this configuration the indicated speed is close to the stall speed and the airplane is generally at rather low altitude.

For a given bank angle, the higher the speed is, the largest the radius of turn will be.
For a given speed, the higher the bank angle is, the smallest the radius of turn will be.

This is important in handling aircraft in holding circuits. The “size” of the circuit can be very different as a function of the aircraft speed and bank angle.

Nevertheless, the protection volume of a published circuit is designed to take into account several parameters, uncertainties and the different possible joining procedures.

6. Performance table

In the table below, some general performances are presented to provide an overall view to the controller.

Aircraft type (examples)	Maximum Operation Speed (IAS)	Approach Speed (IAS)	Minimum Clean Speed (IAS)	Final Approach Speed (IAS)	Minimum Approach Speed (IAS)	Rate of Climb/Descent (ft/min)
General Aviation BE55 C182 C310 PA31 PA46 TB20	120-220 (Vmo)	80-180	75-100	70-110	60-95	C: 500-1500 D: 800-1000
Turboprop AT42 BE90 B350 C130 DHC8 E120 F27 F50 S340	180-280 (Vmo)	150-250	120-150	110-140	80-115	C: 1000-2500 D: 1000-2500
Private jets BJ40 C550 FA20 FA50 HS25 LR35 LR45	230-390 (Vmo)	180-280	150-180	120-150	95-125	C: 1500-5000 D: 1500-5000
Liners A310 A320 B717 B737 B757 CRJ7 DC10 IL62 MD80	220-350 (Vmo)	200-280	170-230	120-160	105-145	C: 1000-3500 D: 1500-3500
"Heavy" Liners A330 A340 B747 B777 MD11 A225	230-360 (Vmo)	200-260	210-250	140-170	125-155	C: 1500-3500 D: 1500-3000