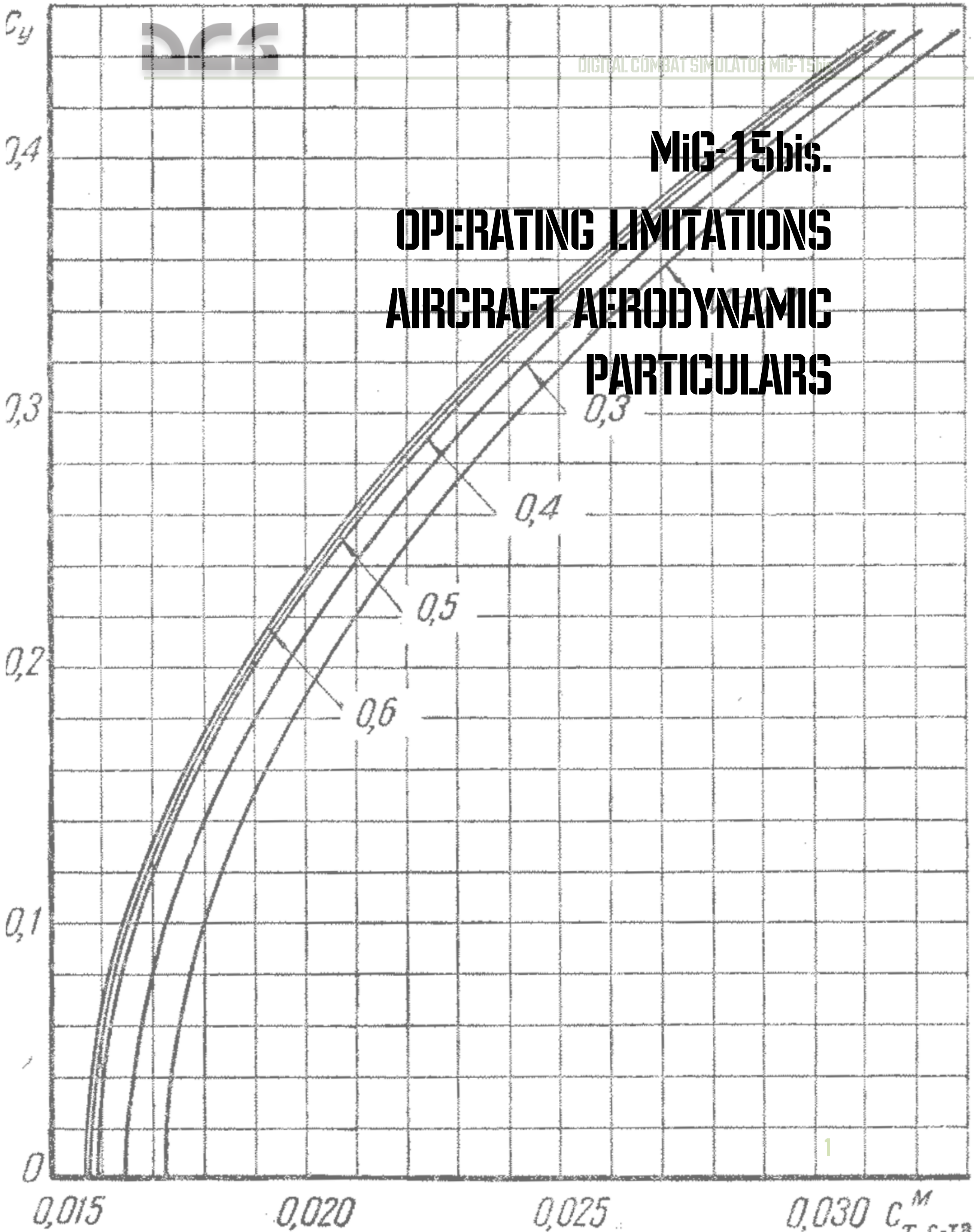
MiG-15bis.

OPERATING LIMITATIONS AIRCRAFT AERODYNAMIC PARTICULARS



1. OPERATING LIMITATIONS

1.1.1. Primary limitations

Maximum load limit (G) for all altitudes: 8

Critical (structural failure) maximum load limit (G): 12

Maximum indicated airspeed (IAS): 1070 km/h

Maximum Mach number (M): 1.0

Maximum air velocity pressure: 5500 kg/m^2

Service ceiling: 15500 m

Maximum load limit of 8 G can only be attained at altitudes below 6400 m. When maximum G for a given altitude and airspeed is approached, the aircraft exhibits a buffet, which can serve as a maximum G warning for the pilot.

1.1.2. Maximum airspeed and Mach number (M) limitations

Absolute maximum attainable airspeed in level flight:

- at low altitudes:
  - TAS (true airspeed, small needle on the airspeed indicator): 1070 km/h
  - IAS (indicated airspeed, large needle on the airspeed indicator): 1060 km/h
- at the service ceiling:
  - TAS: 720 km/h
  - IAS: 300 km/h

Absolute maximum attainable Mach number (M):

- in level flight (attained at an altitude of 11000 m): 0.919
- at low altitudes: 0.877
- at the service ceiling: 0.7

Indicated airspeed limitations:

- IAS 1070 km/h from ground altitude to 900 m
- Maximum airspeed with flaps fully extended to 55°: IAS 400 km/h

- Maximum airspeed for landing gear extension/retraction: IAS 500 km/h

Maximum level flight airspeed with external drop tanks:

- small drop tanks (2 x 300 L):
    - 3500 m: TAS 820 km/h (IAS 700 km/h)
    - 5000 m: TAS 1015 km/h
- large drop tanks (2 x 600 L):
    - 4600 m: TAS 990 km/h (IAS 800 km/h)

Maximum Mach number with external drop tanks:

- small drop tanks (2 x 300 L): M = 0.9
- large drop tanks (2 x 600 L): M = 0.85

Maximum level flight airspeed with open airbrakes:

- ground altitude: TAS 750 km/h (IAS 750 km/h)
- 10000 m: TAS 790 km/h (IAS 482 km/h)

The airbrakes produce a positive pitch moment, which can be used to assist with dive recovery.

NOTE: The DCS MiG-15bis model features enlarged airbrakes with a surface area of 0.8m^2 featured on airframes produced from 1952.

The optimum climbing speed without external drop tanks is practically identical at all altitudes and equals TAS 710 km/h, however the corresponding indicated airspeed drops as altitude increases (to IAS 300 km/h at the service ceiling).

Service ceiling (Vy (climb rate) of 0.5 m/s):

- 15000 m (w/t drop tanks)
- 13400 m (w/ drop tanks)

1.1.3. Minimum airspeed limitations

The minimum airspeeds (indicated) at which the aircraft loses controllability and stalls are as follows, depending on engine power setting:

- Idle power, flaps and landing gear extended: 190 km/h
- Idle power, flaps and landing gear retracted:
    - below 10000 m: 200 - 220 km/h
    - above 10000 m: 230 - 240 km/h
- Idle power, airbrakes open: 200 - 210 km/h

- Max power, climbing, flaps and landing gear retracted: 200 km/h

Minimum control speed at which the control surfaces retain sufficient effectiveness is 300 km/h at altitudes above 12000 m.

Minimum speed for level flight and maneuvering, except takeoff and landing, is set for the aircraft at IAS 300 km/h.

2. AIRCRAFT AERODYNAMIC PARTICULARS

The aerodynamic characteristics and handling particulars described below are based on the SA-64 standard atmosphere model: +15°C, 760 mmHg at sea level.

2.1.1. Climb rate

Time to climb to 5000 m: 1.95 min

Time to climb to 10000 m: 4.9 min

Climb rate reduces significantly as altitude increases. Maximum climb rate is attained at ground altitude: 50 m/s (36.6 m/s w/large drop tanks).

2.1.2. Takeoff and landing characteristics

Primary airspeed references for takeoff and landing

Takeoff ground run distance: (flaps extended to 20°) – 475 m.

- liftoff speed w/t drop tanks and flaps extended to 20° is 220 - 230 km/h, with flaps retracted - 245 km/h.
- liftoff speed with large drop tanks and flaps extended to 20° is 255 km/h, with flaps retracted - 275 km/h.
- final approach speed (prior to flare) with flaps extended to 55° at idle engine power is 250 - 270 km/h.

Touchdown speed with flaps extended to 55°, idle engine power, and at normal landing weight is 190 - 200 km/h.

Landing ground run distance (flaps extended to 55°) - 670 m.

Other takeoff particulars

The takeoff distance and liftoff speed depend on engine RPM setting, flaps setting, and takeoff weight of the aircraft.

From a stopped position, the aircraft is initiated into forward motion at approximately 8000 - 9000 RPM, but can be held in place using the wheel brakes unless engine power is increased further.

Nose wheel liftoff speed is approximately 160 km/h.

After liftoff, the landing gear is retracted at 350 - 400 km/h at an altitude of 10 - 15 m. The landing gear transition time is 6 - 8 sec.

Flaps are retracted at an altitude of 50 - 100 m (after retracting the landing gear).

The ground run distance depends on the type of runway surface and its condition, as well as wheel brake usage.

Other landing particulars

Prior to landing, the landing gear is extended at 400 - 450 km/h (transition time of 8 - 10 sec). The landing approach is initiated at an airspeed of 320 - 350 km/h. Flaps are extended during the approach.

Final approach speed is 250 - 270 km/h, depending on aircraft weight.

The flare is performed at an altitude of 6 - 7 m and completed at 1 m. The engine is set to idle power and the aircraft is held level by applying increasing stick pull to reduce airspeed to the desired touchdown speed of 190 - 200 km/h (depending on weight).

2.1.3. Controllability

The MiG-15 powered by the VK-1 engine can perform all standard aircraft maneuvers. No special handling particulars are exhibited up to Mach 0.86 - 0.87.

At airspeeds exceeding Mach 0.86 - 0.87, the following particulars are exhibited:

a) opposite roll response to pedal input (for example right pedal input leading to left roll)
b) slight reduction of stick force in straight flight

c) increase of stick force required to attain a unit of load (G);

d) uncommanded roll

Pitch trim particulars:

- neutral trim airspeed when climbing at altitudes of 3000 - 5000 m at normal aircraft weights with elevator trim set to neutral and engine power set to nominal 11200 RPM: 520 - 600 km/h
- at altitudes of 3000 - 7000 m throughout the airspeed envelope, the longitudinal stick force required to operate the elevator does not exhibit significant change and use of elevator trim is not required
- at altitudes below 3000 m and airspeeds approaching maximum, the recommended IAS for establishing elevator trim is 800 km/h
- at altitudes above 10000 m, the recommended IAS for establishing elevator trim is 350 km/h

2.1.4. Response to rudder deflection

Aircraft roll response to rudder input in level flight at speeds above 300 km/h corresponds to the direction of pedal input, but is relatively mild due to the wing anhedral angle. However as G increases, the effect becomes more pronounced. As airspeed increases toward Mach 0.84 - 0.86, the roll rate in response to pedal input begins to reduce noticeably. In the Mach 0.87 - 0.95 range, roll response becomes opposite of pedal input. This effect is related to the swept wing design and is caused by reverse roll moments produced by uneven aerodynamic forces of the left and right wing under slip conditions at critical Mach speeds.

2.1.5. Uncommanded roll

Uncommanded roll can occur at high flight speeds throughout the altitude envelope. At altitudes below 4000 m, this can occur at TAS greater than 1070 - 1090 km/h (small needle on the airspeed indicator). As altitude increases, the true airspeed at which uncommanded roll can occur decreases. At altitudes above 11000 m, the true airspeed at which uncommanded roll can occur stabilizes in the 1010 - 1090 km/h range.

Uncommanded roll is corrected by applying opposite stick deflection to maintain the desired roll angle.

It's important to remember:

e) If for some reason TAS exceeds 1070 km/h, the aircraft must be slowed by opening the air brakes and reducing engine power to idle.

f) When applying G (pulling the stick) while flying at speeds approaching maximum for the given altitude, anticipate possible uncommanded roll. In this case, reduce G (reduce stick pull), open the air brakes, then proceed to apply the desired G again.

g) Applying opposite pedal during uncommanded roll at speeds of Mach 0.86 and greater in an attempt to correct the effect can lead to *increased* roll rate and significant lateral stick force. Roll can be reduced in this case by carefully applying pedal *in the direction* of the roll. For example if uncommanded roll is to the left, apply slight left pedal or if uncommanded roll is to the right, apply slight right pedal.

The reasons behind the uncommanded roll condition lie in the technological limitations of aircraft production of the 1950s. It was impossible to produce perfectly symmetrical wing forms for the left and right wings with identical rigidity. At high speeds, the wings are stressed and subject to bending and turning deformation at different amplitudes for the left and right wing due to their slight variance in rigidity. Furthermore, in the transonic speed range, shock waves are not formed simultaneously on both wings due to slight variance in their surface fairings and thicknesses. The lift produced by the wing which experiences transonic shock waves first is immediately reduced compared to the other wing. The resulting variances in angles of attack and shock wave conditions between the two wings produce an unbalanced lateral force and a roll moment uncommanded by the pilot.

Note: All production airframes delivered to the air force were test flown by experienced pilots to determine the specific speed at which the uncommanded roll condition begins to occur.

For increased gameplay dynamics, the DCS MiG-15bis model features a randomized wing rigidity calculation. As such, the specific airspeed at which uncommanded roll occurs and its intensity depend on flight conditions, however the direction of the roll condition (left or right) is randomized with each aircraft "spawn".

2.1.6. Stall and spin

For minimum indicated airspeed at which the aircraft loses controllability and stalls, see section Minimum airspeed limitations.

Flight at speeds below the minimum allowed airspeed results in progressively worsening flight controllability as airspeed drops. At IAS 210 - 220 km/h (large needle on the airspeed indicator) in level flight with the pedals held neutral, the aircraft tends to gently roll to either side, drop the nose below the horizon, lose altitude, but does not enter into a spin. If the control stick is pushed forward to the neutral or slightly forward of neutral position, the aircraft begins to quickly gain airspeed, regain full controllability and maintain straight flight.

If airspeed is reduced by positive G application (pulling of the stick), the aircraft exhibits a buffet 10 - 15 km/h prior to reaching minimum allowed airspeeds. The buffet increases as minimum speed is approached and aileron control becomes increasingly ineffective.

In the buffet phase, a spin can be initiated by pulling the stick fully back and applying full rudder pedal. Initially the aircraft will roll in the direction opposite of pedal input (especially likely in a left spin condition), then pitch down and begin to spin in the direction of pedal input.

The spin can be further aggravated by applying full still deflection in the direction opposite of pedal input as the spin is initiated.

During landing approach with the landing gear and flaps extended, the aircraft maintains stable flight down to IAS 190 km/h. At this speed the aircraft exhibits a characteristic buffet as it begins to "wallow" from one wing to the other and can stall in either direction.

At flight speeds above minimum, if the stick is pulled back with simultaneous pedal input, the aircraft performs a wide barrel roll and enters a spin, gradually leveling the spin axis with the horizon.

Stall recovery

If airspeed drops below minimum for the current flight condition and the stall warning buffet appears, recovery is accomplished by gradual stick forward application and increase of engine power to begin acceleration. As airspeed and controllability is regained, pitch can be increased to attain level flight and continue acceleration to establish the desired flight parameters.

If a stall occurs, pedals are maintained in the neutral position to avoid entry into a spin and the stick is held neutral of forward of neutral. Level flight can be established as airspeed increases above minimum.

Spin recovery

As the aircraft enters into a spin:

h) determine the direction of spin
i) set idle engine power
j) set control stick to neutral (the cockpit features a white line on the instrument panel to help guide the pilot to the neutral position)
k) apply pedal in the direction opposite of the direction of spin.

As the aircraft ceases to spin it will begin to recover airspeed. As IAS 380 km/h (large needle on the airspeed indicator) or greater is reached, complete the recovery by establishing level flight.

2.1.7. Other aerodynamic particulars

Of note is the gradual Cy (lift coefficient) curve beyond critical angles of attack, which provides for safe flight in regards to a stall of either wing.

Optimum aerodynamic efficiency (lift/drag ratio) with retracted flaps equals 14.6 at Mach 0.6, Cy = 0.45, H (altitude) = 0.

Minimum frontal drag Cxmin equals 0.015 at Mach 0.6, Cy = 0, H = 0.

The aircraft exhibits lateral-directional stability throughout the allowed angle of attack envelope, flight control deflection range, and Mach number envelope. The elevators maintain effectiveness.

The aircraft maintains lateral-directional stability and the ailerons and rudder maintain effectiveness throughout the angle of attack envelope and flight control deflection range. The elevators maintain effectiveness throughout the Mach number envelope up to Mach 0.92.

At Mach > 0.92, aileron effectiveness greatly reduces. At low angles of attack (1.5°), ailerons effectiveness is practically zero in the Mach 0.96 - 0.98 speed range.