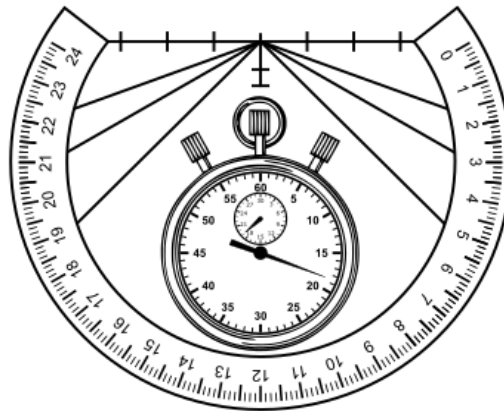


# Handbook for Flight characteristics investigation

A translation of “Handbuch zur Flugeigenschaftsuntersuchung” v1.2

## Handbuch zur Flugeigenschaftsuntersuchung



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## Introduction

The program for determining the flight characteristics of gliders, or Zacher program for short, was revised in the run-up to the IDAFLIEG summer meeting 2011 with the findings of the last few years and improved in detail for the IDAFLIEG summer meeting 2012 (V1.1).

The short-term goal was to adapt the Zachering to the current needs and make it interesting until a more fundamental reorientation takes place. In the medium term, the way should be paved for a reorganization of the determination of flight characteristics in the sense of a system identification.

A first step in this direction was taken in recent years by building a digital Zacher database. This enables the long-term storage of the individual Zacher programs and the sensible use of the determined data.

In the paper "Datenbasierte Evaluation der Flugeigenschaftsuntersuchung für Segelflugzeuge und Motorsegler nach Hans Zacher" ("Data-based evaluation of the flight characteristics study for gliders and powered gliders according to Hans Zacher") [Kastner, 2022], these data were used to draw conclusions about the qualitative and quantitative significance of research methods. Along with the database, a web-based interface, the Zachertool, set up, which enables the pilots to transfer the test results directly to the database. How to use the Zachertool is briefly explained at the end.

## Goal of the current revision

The past IDAFLIEG summer meetings were characterized by a large number of briefings, but also a steadily increasing number of submitted Zacher logs. With the reduced effort achieved through recent adjustments to the Zacher protocol, more briefings can take place in less time and pilots can switch to independent Zachering more quickly. With the increasing number of Zacher flights, the Zacher protocols could be adapted and improved through feedback from the Zacher pilots.

The following goals for the revision have therefore been formulated:

- The Zacher logs are to be adjusted to the log layout of the Zacher website
- The accompanying material is to be adapted to the structure and design of the revised Zacher protocol
- Notes on using the Zacher tool should be entered
- The accompanying material should be more structured and meaningful

## Goal of Zachering

With the instruction in Zachering, interested students should learn and apply scientific flying. This includes subject-specific knowledge (flight mechanics, aerodynamics, human aspects, flight tests, measurement technology, ...), motor skills (deliberate and precise flying of maneuvers), observation skills and the ability to articulate the observations appropriately.

As a central component, it is intended to enable those instructed to plan the basics of flight testing of a glider and to be able to partially carry it out. The Zachering does not include any investigations above the maneuver speed, the slow flight is considered at most up to the point of stalling. So no flight areas are considered that represent a potentially increased risk potential. Further instruction in flight test scenarios, such as flight oscillation tests or spin tests, are possible if required and will be carried out with pleasure.

The origins of zachern go back to a unified, systematic assessment of the flight characteristics of different types of gliders. This assessment formed the basis for the development of the flight characteristics requirements of the modern construction regulations.

In today's objective, the Zachering should do justice to both aspects:

1. On the one hand, an overview of the flight test according to CS-22 should be given, but cannot represent a complete picture. The planned maneuvers represent a representative selection.
2. On the other hand, the selected maneuvers should sharpen the awareness of the various detailed properties behind the question "Why does the airplane fly so well/badly as I think it does?" and provide tools for investigation.

## The execution of Zachering

### Instructions

New pilots are first familiarized with the content and tools on the ground (theoretical instruction). In the following, everyone in the double-seater will be instructed in the practical implementation (practical instruction). If the weather conditions are good, a two-hour flight should suffice, otherwise another flight will be carried out.

Pilots who have already been instructed in the Zachering at previous IDAFLIEG summer meetings will receive a refresher on the Zacher contents before the first flight. The aim is to obtain a uniform view of the investigations and to discuss possible innovations with all those involved.

If necessary, a practical refresher course can also be given to pilots who have already been instructed. Every pilot is asked to assess himself!

The aim of the practical instruction in the two-seater is a demonstration and practice of the maneuvers and processes when Zachering. The focus is on recognizing the purpose of each maneuver. Motorically correct flying is practiced and deepened in the following independent flight characteristics tests.

## Independent Zachering

After the briefing or refresher course, the independent Zachering begins.

For this purpose, the fully trained Zacher pilots can choose one of the gliders available at the IDAFLIEG summer meeting. The IDAFLIEG board assigns a category to each glider and each Zacher pilot. The category of the aircraft must not exceed that of the pilot.

Then, the pilot familiarizes himself thoroughly with the aircraft. This also includes determining the flight mass and center of gravity. The flight and operations manual and the aircraft data sheet filled out by the aircraft operator are to be consulted.

After a Zacher program has been fully processed, there is a discussion with an experienced Zacher pilot who also acts as an instructor. During the submission meeting, the Zacher data should be checked for plausibility and conventions for correct application. During the conversation, errors in the execution of individual maneuvers can also be identified and, if necessary, prompted to repeat them.

## Safety aspects

You are responsible for a safe execution of the flight!

- Make sure you are current with regard to the launch type and general flying!
- Familiarize yourself thoroughly with the aircraft to be flown (manual, etc)! In particular note:
  - Weight and balance
  - Emergency procedures
  - Normal procedures
- Complement your take-off and landing checks with the item "Safely stow away Zacher tools"!
- Zachering demands your attention! Check before every maneuver your surroundings - in addition to the usual lookout - and announce "airspace clear"!
- Do not start maneuvers that include slow flight below 800m above ground!
- 2-hour rule: Zacher flights are limited to a duration of 2 hours, since experience has shown that after that concentration decreases. In exceptional cases, talk to the start director.
- Observe the local conditions and regulations!

## Explanation of the Zacher protocol

The Zacher protocol can be divided into two parts:

**Part 1 - On the ground** consists of a A4 form, front and back. This form is filled in before and after the flight.

**Part 2 - During the flight** consists of a A6 notebook, which is brought along the flight. The individual log points are noted immediately after the respective maneuver has been flown.

## Overview of the protocol

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# Part 1 - Before the flight

## 1 Aircraft information

Also write down the “information about the aircraft”!

Aircraft Manufacturer		Aircraft type	
Registration			

**Objective:** A meaningful and precise documentation of flight tests is essential for evaluating the results. The aircraft data is stored centrally in a digital database, thus it does not have to be documented by every pilot.

Nevertheless, the Zacher pilot is obliged to familiarize himself with the “Information about the aircraft”, which is created in consultation with either the person responsible for the Zachering or the person in charge of the aircraft.

## 2 Speed for comparison

IAS <sub>VG</sub>	km/h IAS
-------------------	----------

**Objective:** CS-22 defines the velocity  $1,4 \times V_{S1}$  as the reference airspeed for turn reversal time. Since flight characteristics are airspeed-dependent, this airspeed is used as a basis for comparison for many of the maneuvers.

In CS-22, this is a calibrated airspeed (CAS). However, since there are usually no reliable flight calibrations for the aircraft under test, only the indicated airspeed (IAS) is available. As a result - in particular when determining the stall speed or  $V_{S1}$  - large errors often occur, resulting in data unsuitable for comparison. In addition, comparison is increasingly difficult when different pilots fly the maneuvers at different airspeeds.

Therefore the comparison airspeed IAS<sub>VG</sub> is defined by the person responsible for the Zachering as an indicated airspeed. It should be used by all pilots for the respective aircraft type. The value is noted on the “information about the aircraft” sheet and can be looked up in the Zacher tool.

### 3 Flight crew details and flight experience

Pilot	Name		Nickname		Attendant	Name	
	Hours	h	Cross country	km		Nickname	
	Height	cm				Height	cm
	Nr. of Types		Hours on type	h			

**Objective:** A meaningful and precise documentation of flight tests and in this case the pilot's flight experience is essential for evaluating the results. The pilot data is stored centrally in the digital database.



## 4 Aircraft loading and center of gravity

Pilot seat	Pilot weight		Lever arm:		Attendant seat	Weight		Lever arm:
	Parachute					Parachute		
	Additional wgt.		Moment:			Additional wgt.		Moment:
	TOTAL:					TOTAL:		

Other	Weight	Lever arm	Moment		Empty Aircraft	Mass:	
						CoG:	
						Moment:	

①	②	③
Sum of all weights	Sum of all moments	Center of Gravity (② ÷ ①)
kg	kg * mm aft ref.pt.	kg * mm aft ref.pt.

**Objective:** A meaningful and precise documentation of flight tests and in this case the exact calculation of the center of gravity of the glider is essential for the evaluation of the results. The tables shown above support the pilot in this calculation. Compliance with the operating limits of the aircraft is also relevant to safety. (Check that the parachute has been counted with the **empty weight** of the glider).

**Execution:** The weights are to be determined independently or the aircraft data to be taken from the data sheet. Also on the aircraft data sheet are the required lever arms for the pilot's seat, possibly attendant's seat and other lever arms for trim weights. The moments are formed as a product of weight and lever arm. The sum of all weights is entered in ① and the sum of all calculated moments in ②. The center of gravity results from the quotient of ② and ①.

## Elevator travel

Before every flight mount the tape measure and fill in the following table:

	<b>7 Stationary circling</b>	<b>17 Static longitudinal stability</b>
Elevator fully forward	mm	mm
Elevator centered	mm	mm
Elevator fully aft	mm	mm

**Objective:** A meaningful and precise documentation of Flight testing is essential for evaluating the results.

**Execution:** The neutral position is best estimated with a helper at the tailplane. In the case of all-flying tailplanes, no neutral position can be determined, only the full deflections.

If points 7 and 17.1 are carried out during a flight, the elevator travel remains identical - as long as the fixed point of the tape measure does not change. If the evaluation is carried out in several flights, the elevator travel can vary and must be noted separately for each log point.

# Part 2 - During the flight

## 5 Start

Launch method(s):

- Winch
- Aerotow
- Self-launch

**Describe the behavior during launch:**

**Purpose of the data point** Describe the behavior of the aircraft during launching. Particular attention should be paid to whether excessive control forces occur, whether the aircraft independently maintains a stable attitude and whether it can be steered back without difficulty after deflection from the normal towing position. (CS22.151).

**Execution** The form should be filled out promptly after releasing.

**Aerotow** Pay particular attention during the initial roll, observe if certain control inputs (deflect rudder, pushing the elevator or extending the air brakes) are effective and whether these measures are recommended (by other pilots or the manual). These should be noted down. After reaching the safety height, a box around the slipstream can be carefully flown. In flapped aircraft, the flap position during initial roll and during tow should be noted.

**Winch launch** Before launching, the trim position and the elevator input should be observed. Your seating position can change due to acceleration. It is important to note whether the elevator input changes and if all controls remain accessible. One should also note the effectiveness of the ailerons and if there's a tendency to excessively rotate. During the climb, it is important to observe the aircraft's attitude and how effectively one can counteract a crosswind component. Anything noteworthy about the automatic release should be noted.

One should be particularly focussed during the take-off, as a large part of gliding accidents occur during take-off. All measurement devices (force-gauges, tape measure, phi-psi-theta, etc.) must be securely stowed so as to not impair control or visibility during the launch.

**Reference to design specification CS-22** CS-22.151 - Aerotow, CS-22.152 - Winch launch

## 6 Trim

The following three aspects of flight characteristics are all influenced by elevator trim.

### 6.1 Trimming range

IAS <sub>min</sub>	km/h <input type="checkbox"/> < V <sub>S</sub>
IAS <sub>max</sub>	km/h <input type="checkbox"/> > V <sub>A</sub>

**Objective:** Fly the possible trim range.

**Instruments:** Airspeed indicator

**Conditions (Altitude, Weather, ...):** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Execution:** The trim is set to fully aft or fully forward, after which the elevator is carefully released until the glider reaches steady flight. If this speed lies above the maneuvering speed V<sub>A</sub>, >V<sub>A</sub> is checked in the log. The same applies if the airplane stalls with the trim fully aft. Then <V<sub>S</sub> is checked.

**Typical errors:** excessive velocity gradient (aim for approx. 1km/h per second).

**Aircraft-specific variations (with/without flaps):** On flapped gliders, use the “Neutral” and “Thermal” flap settings.

**Reference to design specification CS-22:** CS-22.161(c)

### 6.2 Friction difference in straight flight

ΔIAS-	km/h
ΔIAS+	km/h

**Objective:** According to CS-22.173(b), the aircraft must resume the previously trimmed airspeed after a change in airspeed. The difference between the trimmed airspeed and the equilibrium airspeed after a disturbance is called the friction differential speed.

**Instruments:** Airspeed indicator

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals. The maneuver can be combined with the “static” tests.

**Execution:** The aircraft should be carefully trimmed to the comparison airspeed (IAS<sub>VG</sub>) in coordinated straight flight. To determine ΔIAS-, the airspeed should be reduced by about 15 km/h. Then the stick is slowly returned to the trimmed position. Make sure there are no fluctuations in your flight path, and that the increase in speed is less than 1km/h per second. At a speed less or equal than the trimmed speed, you will feel no more forces on the stick. The difference between the speed where this occurs and the previously trimmed airspeed is called ΔIAS-. The ΔIAS+ airspeed is determined in a similar way, apart from using a bigger initial

airspeed difference of 30 km/h above  $IAS_{VG}$ . Take care to be gentle during this maneuver, or the friction differential airspeed cannot be determined. In many gliders the friction is very low and easily overpowered by turbulence and/or unwanted control inputs.

**Convention:** The difference between  $IAS_{VG}$  and the resulting airspeed should be noted.

**Typical results**

- $\Delta IAS-$ : -5 ... 0 km/h
- $\Delta IAS+$ : 0 ... 10 km/h

**Typical errors**

- excessive velocity gradient
- Equilibrium airspeed shifts due to atmospheric influences (thermals, turbulence)

**Aircraft-specific variations (with/without flaps)** On flapped aircraft, use the “Neutral” and “Thermal” flap settings.

**Reference to design specification CS-22** CS-22.173(b)

### 6.3 Extra elevator force in circling

30° bank angle	daN	<input type="checkbox"/> Left <input type="checkbox"/> Right
45° bank angle	daN	<input type="checkbox"/> Left <input type="checkbox"/> Right

**Objective** Determine the effectiveness of the trim during circling at different bank angles.

According to CS-22, given a constant airspeed and trim position, an increasing elevator control force in the aft direction should be required with increasing bank angle.

**Instruments** PhiPsiTheta, Force gauge, Airspeed indicator, Yaw string

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Execution** Establish a coordinated turn at the comparison airspeed ( $IAS_{VG}$ ), and measure the extra required force with the force gauge. The force measurement should be executed at the location of the middle finger on the stick. Generally the forces are quite low, so a small range force gauge is sufficient. Note whether you turned to the left or to the right.

**Aircraft-specific variations (with/without flaps)** On flapped aircraft, use the “Neutral” and “Thermal” flap settings.

**Reference to design specification CS-22** CS-22.143(c)

## 7 Stationary circling

		30° bank angle		45° bank angle	
<b>Ailerons</b>	↓	↺ %	↻ %	↺ %	↻ %
<b>Rudder</b>	↓	↺ %	↻ %	↺ %	↻ %
<b>Elevator</b>	mm	↺ mm	↻ mm	↺ mm	↻ mm

**Objective:** Determine which control inputs are required for steady turns. Quantify these observations using the instruments for this maneuver.

**Instruments:** PhiPsiTheta, Tape Measure, Airspeed indicator

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Execution:** Attach the tape measure, and assume a straight and coordinated flight at  $IAS_{VG}$ . Note down the elevator stick position in straight flight. Then assume a 30° bank angle and then a 45° bank angle. Note down the elevator positions in the fields to the correct turn direction. If possible, fly in both directions.

**Convention:** Control deflections in opposite direction of the turn should be noted with a “-” prefix (for example, aileron).

### Typical results

Given a constant airspeed, with increasing bank angle

- The aileron tends to be deflected in the opposite direction of the turn: -25...0%
- The rudder tends to be deflected in the direction of the turn: 0..20%
- The elevator is deflected further in the “pull” direction.

**Aircraft-specific variations (with/without flaps)** Flapped aircraft should be flown with a more positive flap setting than level flight. For this reason, the maneuver should only be flown in the “thermal” flap setting.

**Reference to design specification CS-22** None

## 8 Slow flight and stall characteristics

$IAS_{uber}$	↻	km/h	↻	km/h
$IAS_{min}$	↻	km/h	↻	km/h
<b>Warnings and stall behavior:</b>				

**Objective:** Determine the stall speeds and stall behavior in three different conditions. The speeds noted are indicated airspeeds rather than calibrated airspeeds.

Stalling should take place with an airspeed gradient of less than 1 km/h per second. According to CS-22, a gradient of about 2 km/h per second should be used. Airspeed gradient can greatly influence the result.

**Instruments:** Airspeed indicator, Yaw String, PhiPsiTheta

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Beware! Do not start below 800m above the ground. Depending on the glider, there is a possibility of entering a spin!**

**Execution:**

Each stall should be approached with a reduction in airspeed of less than 1 km/h per second, while disturbances in bank angle should be corrected.

**8.1 Straight and level flight** Keep the aircraft coordinated in straight-and-level flight using the ailerons and rudder.

**8.2 10° sideslip** Apply rudder input to the direction of the sideslip. Keep your bank angle small using the ailerons.

**8.3 30° bank angle** Keep the Yaw String as long as possible centered during a steady turn.

**Definitions**

$IAS_{uber}$  is reached when for example elevator buffeting (Schtt), unsteadiness in the controls (USt), mushy aileron response occurs. An increase in airflow noise frequency does not necessarily indicate  $IAS_{uber}$ , but could also indicate airflow detachment over the fuselage (AbRu).

$IAS_{min}$  is reached when the aircraft is stalled, shortly before it either pitches forward (Kpf) or for example a wing dip occurs at the left wing (liFI). Variations around the pitch axis are referred to as pitching (Nik) and movement around the Yaw axis are referred to as "tumbling" (Tau).

**Convention and example:** Write down the behaviors in the order in which they occurred. The transition from  $IAS_{uber}$  to  $IAS_{min}$  should be indicated with an arrow.

Schtt, Wch → Tau → liFI means:  $IAS_{uber}$  is indicated by elevator buffeting and simultaneous mushyness of the ailerons. At  $IAS_{min}$ , the aircraft shows variations in pitch and then the left wing dips.

The stall should be performed several times and - if applicable - be flown to the left and to the right. If differences are then found in the behavior, write those down.

**Aircraft-specific variations (with/without flaps)** On flapped aircraft the maneuver should be flown with both the “neutral” and “thermal” flap settings.

**Reference to design specification CS-22** CS-22.49, CS-22.201, CS-22.203, CS-22.207



## 9 Aileron effectiveness

**Objective:** With every aileron deflection, adverse yaw occurs, which counteracts the desired rotation around the vertical axis. If, for example, a full aileron deflection to the left is input quickly (time = 0.5 second) with the rudder held firmly, the glider first turns around the vertical axis to the right without significantly changing the direction of flight. The yaw angle is the angle between the flight path and the longitudinal axis of the glider.

Determine the time needed to reach 30° angle of bank at  $IAS_{VG}$ .

**Instruments:** PhiPsiTheta, Stopwatch, Airspeed indicator, Yaw String

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Execution:** Fly the glider towards a landmark at  $IAS_{VG}$ . Fixate the rudder, then move the ailerons quickly (0.5 second) to one side and leave it fully deflected until the end of the maneuver. Start the stopwatch as soon as you deflect the stick. Stop the stopwatch when the glider reaches 30° angle of bank. At this time, estimate the angle between the longitudinal axis of the aircraft and the landmark and write it down.

The results, in particular the time to be noted, are strongly dependent on the swiftness of the aileron input. Pay particular attention to the time to full deflection of 0.5 seconds. The simultaneous actuation of the ailerons and operation of the stopwatch should not be underestimated. In practice, the stopwatch can be actuated in the 0.5 seconds where aileron input is increased.

The maneuver should be carried out several times until converging values are found (at least 3 times). One can determine the angle of sideslip separately from the time needed to reach 30° angle of bank. Differences between values for rolling to the left or to the right are usually the result of differences in human input.

### Typical results:

- Rolling time to 30° angle of bank: 1,5...2,5s
- Angle of sideslip: 5...25°

### Typical errors:

- Not fixating the rudder
- Transition towards full aileron input too slow, failure to fully deflect ailerons
- Incorrect actuation of the stopwatch
- Dramatic changes in elevator input (check horizon)

**Aircraft-specific variations (with/without flaps)** The results are dependent on aileron deflections and therefore also on the differential control of the ailerons. On many flapped gliders the behavior of the differential control changes with flap setting. Therefore this maneuver must be flown with both "Neutral" and "Thermal" flap settings.

**Reference to design specification CS-22** There is no direct relation to CS-22, only to CS-22.143 Controllability and Maneuverability - General.

## 10 Rudder effectiveness

Recovery time from 30° bank angle	
↻	s
↻	s

**Objective:** Skidding to the right should cause a roll to the right. Record the yaw-roll coupling.

**Instruments:** PhiPsiTheta, Stopwatch, Airspeed indicator, Yaw String

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Execution:** Fly a steady turn at 30° bank angle at  $IAS_{VG}$ . Then quickly apply full rudder deflection in the opposite direction of the turn and hold this until the aircraft has rolled beyond horizontal around the longitudinal axis. Measure and write down the time needed to roll to the horizontal position. Keep airspeed constant using the horizon. Note any irregularities, such as a tendency to pitch up.

The time to be measured is strongly dependent on the swiftness of applying rudder input. The specified transition time of 0.5 seconds must be observed. Correctly observing the horizontal position is challenging. The start of the stopwatch must coincide with the start of rudder application. In practice, the start of the stopwatch during the transition to full rudder is feasible. Particular care should be taken to start from a sideslip-free flight condition, as a small sideslip angle has a major impact on the result.

The maneuver should be flown several (at least 3) times, until converging values are found. Differences between rudder to the left and to the right are usually not expected.

**Typical results:** Rolling time from 30° bank angle to horizontally: 2...4s.

**Typical errors:**

- Failure to fixate the ailerons
- Not applying rudder input fast enough, not applying full rudder input
- Incorrectly timing the maneuver with the stopwatch
- Too much change in elevator input
- Failure to select a suitable reference point
- Failure to fly slip-free during initiation

**Aircraft-specific variations (with/without flaps)** The yaw-roll coupling is mostly dependent on the wing dihedral and should be flown in the "Neutral" flap setting.

**Reference to design specification CS-22** There is no direct relation to CS-22, only to CS-22.143 Controllability and Maneuverability - General.

# 11 Control harmony

	Rudder deflection	Aileron deflection
<b>Start</b>	%	%
<b>End</b>	%	%
<b>Aileron forces</b>	Too small - small - pleasant - high - too high	

**Objective:** Aileron deflection creates adverse yaw. In order to fly slip-free, one compensates this by deflecting the rudder in the same direction as the aileron.

Examine if/how the controls inputs relate during the roll. The aileron control force is judged qualitatively.

**Instruments:** Airspeed indicator, Yaw String

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Execution:** Fly slip-free towards a reference point with  $IAS_{VG}$ . The maneuver is best started with small aileron and rudder deflections and small bank angles ( $10^\circ$ ) and then increased by increasing control inputs and bank angles ( $30^\circ$ ). The longitudinal axis of the aircraft should deviate only slightly from the reference point. Take care to ensure slip-free movement and a constant airspeed.

Between the “start” and “end” (i.e. not during the roll reversal) at least one of the controls has to be fully deflected. The control inputs are estimated in %, as best as possible.

The required aileron control force can be judged with the provided terms, or in your own description.

### Definitions

**Start.** The angle of bank is at its maximum, that is the roll rate is zero. Aileron and rudder are set to the reverse roll direction, with at least one of them 100% deflected. This means that the roll in one direction has been stopped by the initial control deflections which are required for a slip-free roll in the opposite direction. The control inputs should be given as quickly as possible, such that they are set when the maximum bank angle is reached.

**End.** Just before the roll reversal control inputs are set. The bank angle is about  $25...30^\circ$  and the roll rate is maximum.

### Typical errors:

- Side-slipping during the maneuver
- Variation in the airspeed during the maneuver
- Failure to fly the center of the rolls to the reference point, significant change in course during several roll reversals.
- Failure to reach full control input

**Aircraft-specific variations (with/without flaps)** The results depend on the ailerons and thus the differential deflection of the ailerons. In many flapped gliders, this changes with flap position, which is why this maneuver must be carried out in both “Neutral” and “Thermal” flap positions.

**Reference to design specification CS-22** There is no direct relation to CS-22, only to CS-22.143 Controllability and Maneuverability - General.

## 12 Roll rates

	Full inputs	Coordinated
↺		
↻		

**Objective:** Determine the time needed to reverse direction from a turn with 45° bank angle at IAS<sub>VG</sub>, both when all inputs are fully deflected and a coordinated roll.

**Instruments:** PhiPsiTheta, Stopwatch, Airspeed indicator, Yaw String

**Conditions (Altitude, Weather, ...)** The maneuver is to be flown well above traffic pattern altitude. Stay well clear of the influence of thermals.

**Execution:** Establish a steady coordinated turn with 45° bank angle at IAS<sub>VG</sub>. As soon as control inputs for the roll (quickly, time to full input 0.5 second) are given, start the stopwatch. The airspeed must be constant during the maneuver - apart from incorrect indication due to a sideslip angle. Pay special attention to the coordinated case. The maneuver “11. Control harmony” prepares you for this, as this should give you a feeling for coordinated rolling with full inputs. The end of the maneuver is reached then crossing the 45° bank angle. Take care not to reduce inputs prematurely.

Execute the maneuver multiple times, until converging values are found (minimal 3 times).

**Typical results:**

- With full inputs: 2...4s
- Coordinated roll: 2.5...5s

**Typical errors:**

- Failure to establish 45° bank angle at the start or end of the maneuver
- Failure to simultaneously fly the aircraft and operate the stopwatch
- Variation of airspeed during the maneuver
- Failure to find optimal control inputs for fastest coordinate roll rate

**Aircraft-specific variations (with/without flaps)** The results depend on the ailerons and thus the differential deflection of the ailerons. In many flapped gliders, this changes with flap position, which is why this maneuver must be carried out in both “Neutral” and “Thermal” flap positions.

**Reference to design specification CS-22** CS-22.147 - Lateral and directional control: Using an appropriate combination of controls it must be possible to reverse the direction of a turn with a 45° bank in the opposite direction within  $b/3$  seconds ( $b$  is the span in meters) when the turns are made at a speed of  $1.4 VS1$  with wing-flaps in the most positive en-route position, air brakes and, where applicable, landing gear retracted and without significant slip or skid.

## 13 Airbrake forces

Unlocking	daN <input type="checkbox"/> Off-scale
Extending	daN <input type="checkbox"/> Off-scale
Retracting	daN <input type="checkbox"/> Off-scale
Locking	daN <input type="checkbox"/> Off-scale

**Objective:** Determine the forces needed to operate the air brakes quantitatively.

**Instruments:** Force Gauge, Airspeed indicator

**Execution:** The extension and retraction forces are usually dependent on the airspeed, so  $IAS_{VG}$  is used as an example here. At  $1.4 \times V_{S1}$ , this is usually the recommended approach speed and is therefore relevant in practice. After establishing coordinated straight flight at  $IAS_{VG}$ , operate the air brakes slowly and determine the forces that occur.

Should the measurement range of the hand-held force gauge prove insufficient, the gauge must be “calibrated” up to the maximum force and then the forces must be extrapolated. Alternatively, “Off-scale” can be ticked and the maximum measurable force of the gauge can be written down.

**Definitions:** Locking and unlocking forces are always positive. Extending and retracting forces can be negative, when they apply in the direction of the actuation (air brakes being sucked out during extension, air brakes falling down during retraction). If forces are not constant during the range of motion, then write down the maximum value.

**Typical results:** Typically the locking and unlocking forces are larger than the extending and retracting forces.

**Aircraft-specific variations (with/without flaps)** The flap setting has no significant effect on the forces needed to operate the air brakes. They are determined during Zacherung, for example, in the “Neutral” flap setting.

**Reference to design specification CS-22** CS-22.143(c)

## 14 Gear

Extension force	small - moderate - high - too high
Retraction force	small - moderate - high - too high
Remarks:	

**Execution:** Judge the extension and retraction forces of the landing gear - if present - qualitatively. Write down any abnormalities.

**Reference to design specification CS-22** CS-22.143(c)

# Static tests, in calm air before thermal activity

## 15 Free flight

Irregularities found:

None

**Conditions (Altitude, Weather, ...)** The measurement should be flown in still air, before the start of thermals, or after thermals have died out.

**Execution:** After level flight at  $IAS_{VG}$  (yaw-string centered) is established, release both stick and rudder (take particular care in aircraft with an all-flying tail). Any irregularities that occur, such as rotations around the longitudinal and/or vertical axis etc., should be noted. If there are no irregularities, tick the "None" box.

## 16 Dynamic longitudinal stability

	1st oscillation	6th oscillation
IAS <sub>max</sub>	km/h	km/h
IAS <sub>min</sub>	km/h	km/h
Oscil. duration	s	Unstable - indifferent - stable
<input type="checkbox"/> 6th oscillation only possible → <b>Number of oscillations possible with released elevator control:</b>		

**Objective:** Investigate the behavior of the aircraft as the result of a deliberate excitation of a phugoid. The primary aim is to investigate with free controls.

**Instruments:** Stopwatch, Airspeed indicator

**Conditions (Altitude, Weather, ...)** The measurement should be flown in still air, before the start of thermals, or after thermals have died out.

**Execution:** First, carefully trim the aircraft for IAS<sub>VG</sub>. Then reduce the airspeed by 15km/h and stabilize at this airspeed. Then release the control stick (free rudder phugoid).

In order to determine the damping, the minimum and maximum airspeeds observed during the first and sixth oscillation are read from the airspeed indicator and written down.

On aircraft with an all-flying tail, keep your hand close to the stick, since the elevator can tip over, causing the aircraft to suddenly pitch up violently.

Necessary attitude corrections in yaw should be carried out carefully with the rudder, and corrections in roll should be corrected using short and light finger and hand edge strokes against the stick in the right direction. Moving the stick longer than necessary will invalidate the measurement.

Should instability be observed with the elevator control released, or if the stick remains centered due to high friction, write down the number of oscillations it takes to leave the speed range allowed for Zachering.

After that, carry out the maneuver with a fixed stick (fixed control phugoid). The procedure for this is similar to with the controls free, except that the stick is not let go but returned to the position for IAS<sub>VG</sub> (use the tape measure for this).

Any irregularities that occur during the maneuver should be written down.

**Definitions:** The **period of oscillation** is best measured from IAS<sub>min</sub> to IAS<sub>min</sub>.

**Typical results:** Normally the phugoid oscillation in gliders is slightly damped to slightly unstable. If the friction in the elevator control is high (see "6.2 Friction difference in straight flight"), the phugoid can appear to be strongly damped or even appear aperiodic. However, borderline stable behavior (steady state amplitude does not depend on initial conditions) or clearly unstable behavior can also be observed.

The period is usually 15...25s.

**Typical errors:**

- Failure to trim the aircraft at IAS<sub>VG</sub>



- Significant deviations in yaw or roll
- Elevator movement affected by the hand (free control phugoid)
- Returning the stick to slowly or beyond the previously trimmed position

**Aircraft-specific variations (with/without flaps)** The flap setting has no significant effect on the result. The maneuver is flown, for example, in the “Neutral” flap setting.

**Reference to design specification CS-22** CS-22.181 - Dynamic Stability:

Any short period oscillations occurring between the stalling speed and  $V_{DF}$ , must be heavily damped with the primary controls free or fixed.

The phugoid is in this context a “long period oscillation”.

# 17 Static longitudinal stability

## 17.1 Travel

IAS <sub>planned</sub>					
IAS <sub>actual</sub>					
Elev. travel in mm					

**Objective:** Investigate the relation between elevator control travel and the airspeed for slip-free straight flight.

**Instruments:** Tape measure, Airspeed indicator

**Conditions (Altitude, Weather, ...)** The measurement should be flown in still air, before the start of thermals, or after thermals have died out.

**Execution:** Attach the tape measure prior to the maneuver. In the lower airspeed range from IAS<sub>uber</sub> to 120 km/h, increase the airspeed with 10 km/h and above IAS<sub>uber</sub> to about 160 km/h increase with 20 km/h.

Do not exceed the maneuvering speed  $V_A$ . Before writing down the values, make sure the airspeed is constant.

**Typical results:** According to CS-22.173(a), "The slope of the curve, stick displacement versus speed, must not be negative, except that a negative slope may be acceptable provided that it can be demonstrated that there is no difficulty in control."

**Typical errors:**

- Failure to stabilize the airspeed
- Equilibrium airspeed shifts due to atmospheric influences.

**Aircraft-specific variations (with/without flaps)** Generally speaking, the flap setting has a noticeable influence on the result of the maneuver. Therefore, in the context of Zacherin, the maneuver is for example flown in the "Neutral" flap setting.

**Reference to design specification CS-22** CS-22.173(a)

## 17.2 Forces

<b>IAS<sub>planned</sub></b>					
<b>IAS<sub>actual</sub></b>					
<b>Elev. force</b>					

**Objective:** Determine the relation between elevator control force and the airspeed.

**Instruments:** Force gauge, Airspeed indicator

**Conditions (Altitude, Weather, ...)** The measurement should be flown in still air, before the start of thermals, or after thermals have died out.

**Execution:** Detach the tape measure prior to the maneuver. Trim the aircraft for  $IAS_{VG}$  in straight and slip-free flight. If possible, use the force gauge at the position of your middle finger on the stick. In the lower airspeed range from  $IAS_{uber}$  to 120 km/h, increase the airspeed with 10 km/h and above  $IAS_{uber}$  to about 160 km/h increase with 20 km/h.

Do not exceed the maneuvering speed  $V_A$ . Before writing down the values, make sure the airspeed is constant.

**Definitions:** A positive force means forward.

**Typical results:** According to CS-22.173(a), "The slope of the curve, stick force versus speed, must be positive and have a value such that (...)"

**Typical errors:**

- Failure to detach the tape measure
- Failure to trim the aircraft at exactly  $IAS_{VG}$
- Equilibrium airspeed shifts due to atmospheric influences.

**Aircraft-specific variations (with/without flaps)** Generally speaking, the flap setting has a noticeable influence on the result of the maneuver. Therefore, in the context of Zacherin, the maneuver is for example flown in the "Neutral" flap setting.

**Reference to design specification CS-22** CS-22.173(a)

## Part 3 - After the flight

### 18 Landing

Controlability during landing:	
<b>Landing possible using the method described in the handbook?</b>	possible - difficult - impossible

**Objective:** Assess whether unfavorable characteristics such as excessive flare and roll-out distances or premature dropping of a wing can be determined during the landing. Meteorological conditions should be disregarded as far as possible (e.g. long flares due to tailwind components).

**Reference to design specification CS-22 CS-22.153 - Approach and landing**

### 19 Airbrakes

<b>Effectiveness</b>	excellent - good - moderate - bad
<b>Dosability</b>	excellent - good - moderate - bad
<b>Reason</b>	

**Execution:** Evaluate the effectiveness and dosing of the landing aids qualitatively. Explain any anomalies or particularly good/bad ratings.

## 20 Gear

<b>Wheel brake effectiveness</b>	excellent - good - moderate - bad
<b>Wheel suspension</b>	excellent - good - moderate - bad
<b>Substantiation</b>	

**Execution:** Evaluate the effectiveness of the main wheel brake - if available - and the Main wheel suspension qualitatively. Explain any anomalies and particularly good or bad ratings.

## 21 Cockpit

See notes 1+/1/2/3/4/5

	Grade	Substantiation
General impression		
Entry and exit		
Emergency egress		
⋮	⋮	⋮
Release handle		
Instruments		

**Execution:** The cockpit design, arrangement and operation of the controls should be judged subjectively and rated as follows: very good + (corresponds to something worth imitating), very good, good, satisfactory, sufficient, poor.

For assessments that are less than satisfactory, the reasons that lead to this assessment should be given. Solutions that stand out positively should also be explained.

### Other remarks

If there is not enough space for the description of the flight characteristics, design of the cockpit, arrangement and operation of the controls, or if the assessments are particularly bad or good, then further explanations should be given using symbols and abbreviations on the back of the PART II - IN FLIGHT be written down, stating the relevant protocol item.

## Abbreviations

German	English		German	English	
...⇒...	...⇒...	Transition from IAS <sub>uber</sub> to IAS <sub>min</sub>	...→...	...→...	Sequence
...-	...-	sparsely/little	...+	...+	strongly/a lot
Abk		Stalling	liFl		Left wing
AbRu		Flow detachment at the fuselage	nFl		
Absti		Coordination	Nik		
äFl		Outer Wings	QR, Qst		Ailerons, aileron control
BK		Air brakes	Re / re		Right
BR		Wheel brake	reFl		Right wing
ΔIAS		Difference in indicated airspeed	Schtt		Elevator buffet
Fed		Gear bounce	Sfl		Stalled flight
Fstart		Aero tow	SR, SSt		Rudder, rudder pedals
FW		Gear	Tau		Yawing
HR, Hst		Elevator, elevator control	Tru		Spinning
IAS		Indicated airspeed	USt		Unsteadiness in controls
IAS <sub>max</sub>		Maximum indicated airspeed	V <sub>A</sub>		Maneuver speed
IAS <sub>min</sub>		Minimum indicated airspeed	V <sub>S</sub>		Stall speed

IAS <sub>uber</sub>		Airspeed at which first signs of stall exhibit	vFI		
IAS <sub>VG</sub>		Comparison airspeed	Wch		Mushy-ness of aileron control
iFI		Inner Wings	Wstart		Aero tow start
Kpf		Pitching forward	$\psi$		Angle of bank
Li / li		Left	$\beta$		Angle of sideslip

## Notes on the Zachertool website

The Zacher website was developed to enable easy storage of the Zacher log raw data so that it is electronically available for a wide variety of evaluations. Each Zacher pilot should independently transfer the test results to the database. The Zachertool supports this by enabling the entry of the individual log points in a clear and targeted manner.

In addition to the log data, data on the respective pilot and the examined glider are also stored. Each pilot is responsible for updating the pilot data. How this works is explained below. The aircraft data should be submitted or checked and updated by the aircraft managers / attendants. The Zachertool website can be accessed with any Internet-enabled device that has a web browser. However, the interface has been optimized for PCs and the "Firefox" browser, so that errors in the display cannot be ruled out on other devices or browsers. Exact access will be communicated by the IDAFLIEG board or the person responsible for Zacherung.

## Pilot data

To enter a Zacher log, the pilot data must not be older than 90 days. Via the drop-down menu "Piloten" ("Pilots") -> "Pilotenliste anzeigen" ("Show pilot list") all saved pilots are displayed. The pilot can use the search function to find his entry and click on "Anzeigen" ("Show"). From there you can click "Pilotendaten aktualisieren" ("Update Pilot Data"). Otherwise the pilot can save his data via "Neuen Piloten hinzufügen" ("Add new pilot").

When updating the pilot data, make sure that the date of the update is before the date of the flight.

## Entering the log data

Log entry can be accessed via the "Protokolle" ("Logs") -> "Neues Protokoll eingeben" ("Enter new log") drop-down menu. First, the general information on the Zacher log is queried. This



includes the date, flight time and notes on the log. It is also necessary to select which type of log is to be entered. "Zachern ohne ,Statische""("Zachern without 'Static'") contains all log points, except those of the Static tests. If a complete counter log is to be entered with Static tests, both log types must be selected.

On the following pages, important information on the individual log points is highlighted in red and should be observed.

## Flugzeugauswahl - Aircraft information

The evaluated airplane can be selected from the list of saved planes. This is facilitated by the search function. Also in this step the pilot's flight time on the selected type is entered.

## Pilotenauswahl - Pilot information

Pilot selection only displays pilots whose data has been updated in the last 90 days prior to the log date. Creating a new pilot or updating pilot data can be accessed directly from the page. This discards any entered data. In the case of two-seaters, an existing pilot or the empty field can be selected for the companion. The accompanying weight - if available - is then entered manually in the next step.

## Angaben zur Beladung - Load and balance information

A weight can be entered here for each lever arm that is defined in the aircraft data record. At least the pilot's weight and the associated parachute weight (can also be 0kg) must be entered. For two-seaters, a parachute weight must also be present if an attendant weight has been entered. If another weight is used for which no lever arm is defined in the database, this can also be added.

The center of gravity is automatically calculated with the given weights and lever arms. If the automatically calculated value deviates from the value calculated by the pilot, the manual value should also be entered.

## weitere Protokollpunkte - other data

The test results are entered in the same form as they are recorded in the Zacher log. Some input fields only allow a certain input range (e.g. percentages only from 0 to 100). The unit - if available - is to be considered.

For maneuvers where direction is important, the direction in which the maneuver was performed can be specified. If the elevator position is required for a maneuver, the total elevator range should be repeated at the respective log point in order to improve accuracy.

For some log points it is possible to add a comment in addition to the examination results. Comments on the execution of the maneuver, but also on meteorological conditions or anything else can be written down.

## Zwischenspeichern und Absenden - Saving a draft and sending

The log can be saved as draft at any time as soon as at least one test result has been entered. The saving as a draft is done by clicking on "Speichern und Zurück"("Save and Back"). A saved protocol can be continued by selecting the corresponding protocol for editing via the drop-down menu "Protokolle"("Logs") -> "Begonnene Protokolle anzeigen"("Show started protocols").

On the last page of the log entry, instead of the "Weiter"("Next") button, there is a "Absenden"("Send") button. Sending should take place after all examination results have been transmitted. After sending, the log can be found under "Protokolle"("Logs") -> "Fertige Protokolle anzeigen"("Show finished logs"), but it can still be edited.

## Abgabegespräch - Submission meeting

During the submission meeting, the test results are discussed in detail and checked for plausibility. For this purpose, the "finished" protocol can be displayed, discussed and, if necessary, edited. After the submission meeting, the cashier marks the protocol as "submitted". The log can now be found under "Protokolle"("Logs") -> "Abgegebene Protokolle anzeigen"("Display submitted logs") and cannot be edited further. In addition, it is only included in the statistics from this point in time.