

### Features

- Flow velocities up to 40m/s possible
- Homogeneous flow through the flow straightener and special nozzle contour
- Matching accessories offer a wide range of experiments

Aerodynamics describes the behavior of bodies during flow around or through bodies with a compressible fluid. The purpose of experiments in aerodynamics is familiarization with and optimization of drag and the flow field around a body. This knowledge has a significant influence on the development of means of transport (vehicles, ships, aircraft) and in architecture (skyscrapers, towers and bridges).

**TESCA Aerodynamic Trainer Model 32448** offers –

along with its accessories – typical experiments from the field of flow around, incident flow and flow through models, as well as further experiments in the field of steady incompressible flow.



The trainer includes a radial fan, which can be used to generate flow velocities up to 40m/s. The speed is infinitely adjustable by using a frequency converter. A stabilization tank with flow straightener ensures a consistent, low-turbulence and reproducible flow in the measuring section. A carefully shaped nozzle provides a largely homogeneous velocity distribution of the air flow. The accessory is attached using quick release fasteners and can be interchanged quickly and easily. Measuring points along the measuring section allow pressure and velocity measurements to be taken. The tube manometers are used to show the pressures clearly.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

### Specifications

01. Aerodynamics experiments in the fields of flow around, incident flow and flow through models, as well as further experiments in the field of steady incompressible flow.
02. Vertical measuring section with flow straightener and nozzle
03. Radial fan infinitely variable via frequency converter
04. Thermometer for measuring air temperature
05. Accessory securely attached to 32448 with quick release fasteners
06. 16 tube manometers for displaying pressures
07. Accessories for the field of flow around bodies:
  - Boundary Layers
  - Drag Forces
  - Coanda Effect
  - Visualisation of Streamlines
08. Accessories for the field of steady incompressible flow:
  - Bernoulli's principle
  - Flow in a pipe elbow
  - Free Jets

Note: Specifications are subject to change.

## Technical Specifications

### Radial fan

- Power consumption: 0,37kW
- Max. flow rate: 15m<sup>3</sup>/min
- Nozzle exit cross-section: 50x100mm
- Max. flow velocity at the nozzle exit: 40m/s

### Experiments

Together with appropriate accessories: experiments from the field of flow around bodies

- Velocity measurement of flows with Pitot tube
- Boundary layer analysis on a flat plate with flow along the plate
- Drag of bodies
- Demonstration of the Coanda effect
- Visualisation of streamlines

Together with appropriate accessories: experiments from the field of steady incompressible flow

- Velocity measurement of flows with Pitot tube and Pitotstatic tube
- Free jets
- Flow in a pipe elbow
- Proof of Bernoulli's principle

### Scope of Delivery

- 1 trainer
- 1 set of instructional material

## ATTACHMENTS

### 01. Boundary Layers Model 32448.1

#### Features

- \* Investigation of the boundary layer at two different rough surfaces
- \* Boundary layer interference with pressure profile
- \* Accessories for aerodynamics trainer **32448.1**



During incident flow of bodies fluids such as air "stick" to the surface of the body and form the so-called boundary layer. The kind of flow within the boundary layer - laminar or turbulent - significantly affects the drag.

The findings from studying the boundary layer are taken into consideration when designing aeroplanes, vessels and turbo machines.

**TESCA Boundary Layers Attachment Model 32448.1** experimental unit - used in the aerodynamics trainer **32448** allows the boundary layer on a flat plate to be studied. For this purpose, air flows along the plate, parallel to the surface. The plate has two different surfaces so as to study the effect of surface conditions on the boundary layer. Side bodies can be used in the measuring section. Thus the boundary layer phenomena can experience interference with a degressive or progressive pressure curve and, for example equalize the friction loss of the flow.

A horizontally movable pitot tube, adjusted using a micrometer screw, measures the total pressures at various distances from the plate surface. The plate can be moved vertically to enable the recording of total pressures in the direction of flow. The velocity can be determined from the pressures read off the tube manometers in **32448**

The experimental unit is attached to the air outlet of the **32448** trainer, simply and precisely with quick release fasteners.

Note: Specifications are subject to change.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

### Specifications

01. Investigation of boundary layers on a flat plate with flow along the plate
02. Accessories for the aerodynamics trainer **32448**
03. Plate with two different rough surfaces
04. Moveable plate, along the direction of flow
05. Pitot tube for measuring the total pressure at the plate
06. Adjustment of the pitot tube to the plate using micrometer screw
07. Removable side bodies for interference of the boundary layer with degressive or progressive pressure profile
08. 16 tube manometers of **32448** for displaying the dynamic pressures

### Technical Specifications

#### Pitot tube

- Diameter: 0,7mm
- Movable: 0,35...50mm Plate, movable: 0...250mm
- LxW: 260x55mm, thickness: 5mm
- Chamfer: 30°
- Smooth surface: 25µm
- Rough surface: 400µm 2 side bodies, removable
- Inclination: 1:12,5

### Experiments

- Internal friction of gases
- Investigation of the boundary layer on the flat plate
- Influence of surface roughness on the formation of a boundary layer
- Boundary layer interference with degressive/progressive pressure curve

### Scope of Delivery

- 1 experimental unit
- 1 plate
- 2 side bodies

### 02. Bernoulli's Principle Model 32448.2

#### Features

- \* Investigation of Bernoulli's equation
- \* Determination of the dynamic pressure
- \* Calculation of the flow velocity
- \* Accessory for aerodynamics trainer **32448**



The total pressure in a steady flow is constant. The sum of the static and dynamic pressures gives the total pressure. A change in the cross-section of the flow channel causes the flow velocity to vary inversely proportional to the cross-sectional area. These physical laws are fundamentals of fluid mechanics education. **TESCA Bernoulli's Principle Attachment Model 32448.2** experimental unit – used in the aerodynamics trainer **32448** allows the measurement of the total pressure and the static pressure. A model is placed in the measuring section, which uses lateral bodies to produce a Venturi -shaped cross sectional profile of the flow.

At the centre of the flow channel there is a Pitotstatic or Prandtl tube. The Pitotstatic tube has an opening opposite to the flow direction to measure the total pressure. The static pressure is measured through lateral inlet openings. Both pressures are read from the tube

Note: Specifications are subject to change.

manometers in 32448. The dynamic pressure is the difference between both measured values.

In order to illustrate pressure and velocity distribution, measurements can be taken at different cross-sectional areas by moving the Pitotstatic tube in the flow direction. The experimental unit is attached to the air outlet of the **32448** trainer, simply and precisely with quick release fasteners.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

### Specifications

01. Investigation of the continuity equation and Bernoulli's principle
02. Measurement of the total pressure and the static pressure in a steady flow
03. Accessory for the aerodynamics trainer **32448**
04. 16 tube manometers of **32448** for displaying the pressures

### Technical Specifications

#### Pitotstatic tube

- $d=2\text{mm}$
- Movable:  $0\text{...}290\text{mm}$

### Experiments

- Investigation of the continuity equation and Bernoulli's principle
- Determination of the dynamic pressure from the measurement data via Bernoulli's principle
- Calculation of the flow velocity from the measurement data using Bernoulli's equation
- Pressure and velocity distribution

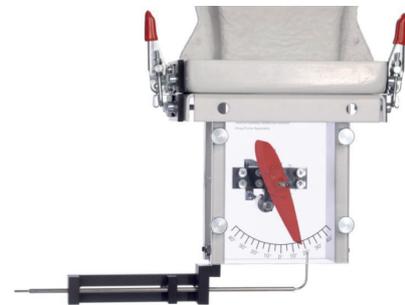
### Scope of Delivery

- 1 experimental unit
- 1 set of hoses

### 03 Drag Forces Model 32448.3

#### Features

- \* Determining drag forces on models immersed in a flow
- \* Accessories for aerodynamics trainer **32448**



Every body immersed in a flow is subject (besides hydrostatic lift) to a flow-induced force, which depends mainly on the velocity of flow, the size of the body and the shape of the body. The shape of the body is represented by the dimensionless number, the drag coefficient  $c_d$ .

The goal of scientific study and practical application (e.g. in vehicle construction) is to design the perfect body shape in order to keep drag low. The drag coefficient for arbitrarily shaped bodies can only be determined reliably by experimentation.

**TESCA Drag Forces Attachment Model 32448.3** experimental unit - used in the aerodynamics trainer **32448** allows drag to be measured in various models so as to determine the respective drag coefficients. In the measuring section, a model (plate, cylinder and aerofoil model) is used as a drag body. The forces occurring in the air flow are measured with a beam scale with movable weight. When conducting the experiment with a cylinder, a Pitot tube can be used to record a pressure distribution of the surrounding flow.

Note: Specifications are subject to change.

Also, the drag can be measured indirectly via the pulse rate. The Pitot tube, movable obliquely to the direction of flow, allows pressures to be recorded so as to determine the velocity profile downstream of the cylinder and thus to gauge the so-called wake depression.

The experimental unit is attached to the air outlet of the **32448** trainer, simply and precisely with quick release fasteners.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

### Specifications

01. Determining drag forces on models immersed in a flow
02. Recording the pressure distribution on models immersed in a flow
03. Recording the velocity profile for measuring the wake depression behind the cylinder immersed in a flow
04. Accessories for the aerodynamics trainer 32448
05. Models: plate, cylinder and aerofoil model as drag body
06. Cylinder with additional pressure measuring point
07. Pitot tube with horizontal adjustment for measuring the total pressures

### Technical Specifications

#### Pitot tube

- Diameter: 1,1mm
- Horizontal adjustment: 50...0...50mm  
Measuring section: cross-section 50x100mm  
Angle scale: -40...40°  
Weights: 1x10g, 1x40g  
Drag body
- Plate: LxW: 45x15mm, thickness: 1mm
- Cylinder: DxH: 15x45mm
- Aerofoil model: LxWxH: 100x15x45mm

### Experiments

- Measure drag forces on models immersed in a flow
- Determining drag coefficients
- Application of the pulse rate
- Record pressure distribution on the cylinder immersed in a flow
- Measure the wake depression behind the cylinder immersed in a flow

### Scope of Delivery

- 1 experimental unit
- 3 drag bodies

### 04. Flow in a Pipe Bend Model 32448.4

#### Features

- \* Investigation of the pressure curve at a 90° pipe bend
- \* Separation vortex and secondary flow
- \* Accessory for aerodynamics trainer **32448**



When laying pipes it is essential that they are adapted to the circumstances of their environment, which means the pipes will necessarily include deflections in the form of bends. Changing the direction of flow in a pipe changes the pressure conditions. The pressure curve during a change in the flow direction is investigated using the example of a 90° pipe bend.

Note: Specifications are subject to change.

**TESCA Flow in a Pipe Bend Model 32448.4** when used in the aerodynamics trainer 32448, allows the measurement of the static pressure at 28 pressure measuring points along the pipe bend. The transparent pipe bend has a constant rectangular cross-section with 10 pressure measuring points each on the top and bottom. Four pressure measuring points are located in the region of the curvature on both sides. The pressure measuring points are connected to the tube manometers in **32448** via the hoses supplied. The static pressures can be read on the tube manometers.

To illustrate the pressure distribution, the static pressure at a measuring point is related to the maximum pressure. The graphical representation of the pressure curve shows a low pressure along the inner radius and an over pressure along the outer radius. Secondary flows occur to compensate for the pressure difference. As a result of friction at boundary layers there are separation vortices at the inner radius.

The experimental unit is attached to the air outlet of the **32448** trainer, simply and precisely with quick release fasteners.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

### Specifications

01. Determining the pressure conditions in flow through a pipe bend
02. Measurement of static pressure at 28 pressure measuring points along the bend
03. Ten pressure measuring points each on the top and bottom plus four pressure measuring points on each side
04. Accessory for aerodynamics trainer 32448
05. 16 tube manometers of 32448 for displaying the pressures

### Technical Specifications

#### Pitot tube

- Diameter: 1,1mm
- Horizontal adjustment: 50...0...50mm  
Measuring section: cross-section 50x100mm  
Angle scale: -40...40°  
Weights: 1x10g, 1x40g  
Drag body
- Plate: LxW: 45x15mm, thickness: 1mm
- Cylinder: DxH: 15x45mm
- Aerofoil model: LxWxH: 100x15x45mm

### Experiments

- 90° pipe bend: cross-section 50x100mm
- 28 pressure measuring points

### Scope of Delivery

- 1 experimental unit
- 1 set of laboratory hoses

Note: Specifications are subject to change.

## 05. Coanda Effect Model 32448.5

### Features

- Investigation of wall-guided air flow (Coanda effect)
- Familiarisation with the principle of pneumatic logic elements
- Study amplification effect in pneumatic elements



The Coanda effect refers to the characteristic of flowing fluids to follow the curvature of a convex surface instead of continuing in the original direction of flow. Nowadays this effect is applied in various fields of engineering, e.g. to increase lift in air travel, to control the air flow in air conditioning or as a pneumatic logic element in industrial control systems. Pneumatic logic elements have the advantage that they do not wear out, they work reliably and are resistant to heat, ionising radiation and vibration. The direction of flow in pneumatic logic elements is switched with a turbulent free jet (control jet), which for example, emerges from a nozzle and entrains the fluid from the environment (boundary layer). Since the control jet is usually weaker than the jet to be deflected, we refer to the amplification effect.

**TESCA Coanda Effect Attachment Model 32448.5** experimental unit - used in the **32448** Aerodynamics Trainer - allows the demonstration of the Coanda effect on a pneumatic logic element.

The air flows through a Y-shaped channel with two outlets. The lateral inflow of air into the channel (control jet) can switch the air flow between the two outlets.

The contour of the channel is varied via pivoting and sliding elements, so as to study how the switchover works. Scales allow precise adjustment of the elements.

The experimental unit is attached to the air outlet of the **32448** trainer, simply and precisely with quick release fasteners.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

### Specifications

01. Demonstration of the Coanda effect in pneumatic logic elements
02. Accessories for 32448 Aerodynamics Trainer
03. Transparent plate with vertical, horizontal and radial scales
04. Y-channel with pivoting and sliding elements and vertical sliding wedge for adjusting different contours
05. Adjustable contours for varying the air flow

### Technical Specifications

#### Nozzle outlet

- Width: 0...50mm
- Length: 100mm
- Pivoting and sliding elements: 0...90°
- Wedge, sliding: 0...140mm

### Experiments

- Investigation of wall-guided air flow (Coanda effect)
- Familiarisation with the principle of pneumatic logic elements
- Study amplification effect in pneumatic elements

Note: Specifications are subject to change.

### Scope of Delivery

- 1 experimental unit

### 06. Free Jet Model 32448.6

#### Features

- Investigation of flow course and pressure losses at flow outlet into resting surroundings
- Accessory for aerodynamics trainer 32448



Flow and pressure losses occur when a parallel flow exits into stationary surroundings. The velocity of the exiting flow decreases depending on the distance and diameter of the outlet area. The velocity decreases with increasing distance from the middle jet. The findings from the velocity profiles are used for example in the construction of nozzles and turbomachines.

**TESCA Free Jet Attachment Model 32448.6** experimental unit – used in the aerodynamics trainer 32448 allows the measurement of the velocity curve in the outlet jet. The total pressures are measured at defined distances from the outlet area in the vertical and horizontal direction by means of a movable Pitot tube. Pressures read on the tube manometers in 32448 can be used to determine the velocity. The graphical representation of the velocity profile indicates a decrease in velocity with increasing distance of the measurement from the middle jet and the outlet area. Vortex formation at boundary layers leads to the reduction in velocity due to the loss of energy.

The experimental unit is attached to the air outlet of the 32448 trainer, simply and precisely with quick release fasteners.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

#### Specifications

01. Determination of the pressure loss in the flow outlet into stationary surroundings
02. Accessory for aerodynamics trainer 32448
03. Pitot tube, can be moved horizontally and vertically
04. 16 tube manometers of 32448 for displaying the pressures is recommended

#### Technical Specifications

##### Pipe socket, plastic

- Inner diameter: 54mm

##### Pitot tube, sliding

- Horizontal: -150...150mm
- Vertical: 0...700mm
- Inner diameter: 2mm

#### Experiments

- Recording the pressure curve at the outlet of a parallel flow into resting surroundings
- Representation of velocity profiles

### Scope of Delivery

- 1 Experimental Unit.

Note: Specifications are subject to change.

## 07. Visualization of Streamlines Model 32448.7

### Features

- Visualization of streamlines flowing around and through models
- Fog generator is included
- Accessories for **32448** Aerodynamics Trainer



Streamlines can be visualized in steady flow in the wind tunnel by using fog, smoke or tufts. In this way, a clear impression of an instantaneous flow field flow can be presented and problematic flow areas, such as stall, can be shown.

**TESCA Visualization of Streamlines Attachment 32448.7** experimental unit - used in the **32448** Aerodynamics Trainer - allows the streamlines to be visualized using fog. In the fog generator supplied a fog fluid is evaporated and inlet into the wind tunnel via a slotted pipe. A model (aero-foil, cylinder, orifice plate) is located in the measuring section, around and through which the fog flows. The flow course for the flow around and through becomes visible, as does flow separation.

The measuring section has a black background and a transparent front plate for better observation of the streamlines. The aerofoil model's angle of attack is adjustable. The fog fluid is non-toxic, water soluble and the precipitate does not affect common materials. Precipitates can be easily wiped off with a cloth.

The experimental unit is attached to the air outlet of the **32448** trainer, simply and precisely with quick release fasteners.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

### Specifications

01. Visualisation of streamlines by using fog
02. Accessories for 32448 Aerodynamics Trainer
03. Vertical measuring section with transparent front plate and black background
04. Fog generator, operation with non-toxic and water-soluble fog fluid
05. Three models for insertion into the wind tunnel
06. Aerofoil with adjustable angle of attack
07. Scale for displaying the angle of attack

### Technical Specifications

#### Measuring section

- Cross-section in the viewing area: 252x42mm

#### Models

- Aerofoil, adjustable angle of attack
- Orifice plate
- Cylinder

#### Experiments

- illustrative demonstration without detection or analysis of measured values
- flow patterns in real fluids when flowing around and through models
- \* aerofoil with adjustable angle of attack
- \* cylinder
- \* orifice plate for change in cross-section
- flow separation and stall

#### Scope of Delivery

- 1 experimental unit
- 1 set of models
- 5L fog fluid

Note: Specifications are subject to change.