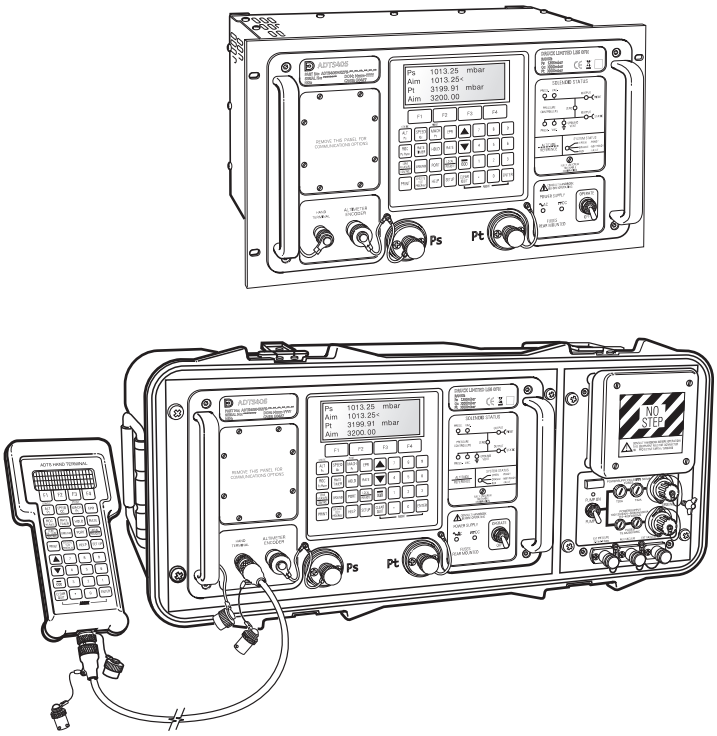
Druck
a Baker Hughes business

ADTS403/405

Air Data Test System

Calibration Manual



Druck.com

Introduction

This technical manual provides calibration instructions for the Druck ADTS403/405 Air Data Test Systems.

Scope

This technical manual contains the calibration instructions for the calibration technician of this equipment series.

Software

This technical manual applies to software DK 127 version 4.20+, DK 263 version 6.0+, DK 415 version 1.03+.

Safety

The manufacturer has designed this product to be safe when operated using the procedures detailed in this manual. Do not use this product for any other purpose than that stated.

This publication contains instructions that must be followed to make sure safe operation and to maintain the equipment in a safe condition. The safety instructions are either warnings or cautions issued to protect the user and the equipment from injury or damage.

Use qualified[1] personnel and good engineering practice for all procedures in this publication.

Pressure

Do not apply pressure greater than the maximum safe working pressure to the equipment.

Maintenance

The equipment used with this software must be maintained using the manufacturer's procedures. Maintenance should be carried out by authorized service agents or the manufacturer's service departments.

Technical Advice

For technical advice contact the manufacturer or subsidiary.

1. A qualified technician must have the necessary technical knowledge, documentation, special test equipment and tools to carry out the required work on this equipment. For procedures in Section 5 ("Calibration using IEEE 488 SCPI") a qualified person must be trained and qualified in both IEEE 488 communications and test programming.

Symbols

Symbol	Description
CE	This equipment meets the requirements of all relevant European safety directives. The equipment carries the CE mark.
UKCA	This equipment meets the requirements of all relevant UK Statutory Instruments. The equipment carries the UKCA mark.
	This symbol, on the equipment, indicates a warning and that the user should refer to the user manual.
	This symbol warns the user of the danger of electric shock.
	Druck is an active participant in the UK and EU Waste Electrical and Electronic Equipment (WEEE) take-back initiative (UK SI 2013/3113, EU directive 2012/19/EU). The equipment that you bought has required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment. In order to avoid the dissemination of those substances in our environment and to diminish the pressure on the natural resources, we encourage you to use the appropriate take-back systems. Those systems will reuse or recycle most of the materials of your end life equipment in a sound way. The crossed-out wheeled bin symbol invites you to use those systems. If you need more information on the collection, reuse, and recycling systems, please contact your local or regional waste administration. Please visit the link below for take-back instructions and more information about this initiative.  **https://druck.com/weee**

WARNING Turn off the source pressure and carefully vent the pressure lines before disconnecting or connecting the pressure lines. Proceed with care.

Only use equipment with the correct pressure rating.

Before applying pressure, examine all fittings and equipment for damage. Replace all damaged fittings and equipment. Do not use any damaged fittings and equipment.

Do not exceed the maximum working pressure of the instrument.

RISK OF ELECTRIC SHOCK The ground lead of the instrument must be connected to the AC supply protective safety ground.

Isolate the power supply before making any electrical connections.

Associated Documents

Document	Title
K0114	ADTS405 User Manual
K0242	ADTS401 Operator's Manual [software version 4.20 to 4.29]
K0243	ADTS401 Operator's Manual [software version 4.31 to 4.39]
K0285	ADTS403 User Manual
K0154	ADTS405 IEEE 488 Option User Manual
K0157	ADTS405 SCPI User Manual

Abbreviations

The following abbreviations are used in this manual; the abbreviations are the same in the singular and plural.

Abbreviation	Description
A	Ampere
abs	Absolute
AC	Alternating current
ADTS	Air data test system
ALT	Altitude
ARINC	Aeronautical Radio Incorporated
ASCII	American Standard Code for Information Interchange
ATE	Automatic test equipment
CAS	Calibrated airspeed
e.g.	For example
etc.	And so on
Fig.	Figure
ft	Foot
g	Gauge
hPa	Hecto Pascal
Hz	Hertz
i.e.	That is
IEEE 488	Institute of Electrical and Electronic Engineers standard 488 data
in	Inch
inHg	Inches of mercury
inH_2O @ 4°C	Inches of water at 4°C
inH_2O @ 20°C	Inches of water at 20°C
kg	Kilogram

Abbreviation	Description
LSU	Line Switching Unit
m	Metre
mA	Milliampere
max	Maximum
mbar	Millibar
min	Minute or minimum
mm	Millimetre
mmHg	Millimetre of mercury
mV	Millivolts
No.	Number
Pa	Pascal
PC	Personnel computer
Ps	Pressure static
psi	Pounds per square inch
Pt	Pressure Total (Pitot)
P/W	Password
Qc	Differential pressure
SCPI	Standard commands for programmable instruments
TAS	True airspeed
TPM	Test program manager (Druck software package)
V	Volts
+ve	Positive
-ve	Negative
°C	Degrees Celsius
°F	Degrees Fahrenheit

Glossary

The terminology used in this manual is specific and individual interpretation must not be introduced. The terms are defined as follows:

Item	Description
Adjust	To bring to a more satisfactory state; to manipulate controls, levers, linkages, etc. to return equipment from an out-of-tolerance condition to an in-tolerance condition.
Align	To bring into line; to line up; to bring into precise adjustment, correct relative position or coincidence.
Assemble	To fit and secure together the several parts of; to make or form by combining parts.

Item	Description
Calibrate	To determine accuracy, deviation or variation by special measurement or by comparison with a standard.
Check	Make a comparison of a measure of time, pressure, temperature, resistance, dimension or other quality with a known figure for that measurement.
Disconnect	To detach the connection between; to separate keyed or matched equipment parts.
Dismantle	To take apart to the level of the next smaller unit or down to all removable parts.
Examine	To perform a critical visual observation or check for specific conditions; to test the condition of.
Fit	Correctly attach one item to another.
Inspect	Review the work carried out by Specialists to ensure it has been performed satisfactorily.
Install	To perform operations necessary to properly fit an equipment unit into the next larger assembly or system.
Maintain	To hold or keep in any particular state or condition especially in a state of efficiency or validity.
Make sure	To confirm that a proper condition exists; to find out with certainty.
Operate	Ensure that an item or system functions correctly as far as possible without the use of test equipment or reference to measurement.
Readjust	To adjust again; to move back to a specified condition; to bring back to an in-tolerance condition.
Reconnect	To rejoin or refasten that which has been separated.
Refit	Fit an item which has previously been removed.
Remove	To perform operations necessary to take an equipment unit out of the next larger assembly or system. To take off or eliminate. To take or move away.
Repair	To restore damaged, worn out or malfunctioning equipment to a serviceable, usable or operable condition.
Replace	Remove an item and fit a new or a serviced item.
Reset	To put back into a desired position, adjustment or condition.
Service	To perform such operations as cleaning, lubricating and replenishing to prepare for use.
Test	Ascertain by using the appropriate test equipment that a component or system functions correctly.

Contents

1. Introduction

The ADTS403/405 incorporates an automated calibration facility providing three different calibration functions. A calibration enable switch, located on the front panel under a label protects the calibration facility. For the ADTS to stay accurate, a calibration check should be carried out at chosen intervals. If the accuracy of the ADTS is not within the specification, carry out a main calibration.

1.1 Calibration Process

The automated calibration facility contains three functions:

- Calibration check
- Main calibration
- Rate calibration

The options for the calibration check and main calibration are:

- Ps (static) channel - absolute calibration.
- Pt (pitot) channel - absolute calibration.
- Ps and Pt (combined) channels - absolute calibration.

The combined static and pitot channel calibration provides a quick calibration method that minimizes errors between static and pitot due to the calibration standard non-repeatable errors.

1.2 Calibration Description

1.2.1 Calibration Check

This is used to check the calibration without adjusting it. It may be used either to see if the ADTS requires a calibration or to verify performance following a main calibration.

Three options are available for main calibration and calibration check:

a. Ps channel - absolute calibration.

b. Pt channel - absolute calibration.

c. Combined Ps and Pt channels - absolute calibration.

The combined Ps and Pt calibration is the quickest to perform and minimizes errors between Ps and Pt due to calibration standard uncertainties.

The calibration can be performed with the ADTS403/405 as the pressure source or by using a pressure standard as the pressure source. The recommended method is to use the ADTS as the pressure source as this is the normal mode of operation of the equipment.

1.2.2 Main Calibration

The main calibration adjusts the accuracy of the main transducers. The procedure applies known pressures to the ADTS and then entering the exact applied pressure using the hand-terminal or local key-pad. After all calibration points have been entered, the ADTS automatically calculates the necessary offset (zero) and slope (span) corrections.

The date of this procedure is logged and displayed during the power-up routine.

1.2.3 Rate Calibration

This function aligns the control transducers with the main transducer to ensure accurate rate control. Rate calibration does not affect the pressure measurement accuracy.

1.3 IEEE 488 SCPI Interface

Calibration facilities are also available over the IEEE 488 SCPI interface. These comprise the following:

- Automatic calibration check and rate calibration as above. These may be performed in either measure mode or control mode.
- A lower level facility allowing multi-point adjustment of curve fit as well as direct setting of offset and slope. A computer algorithm provides automation of this process.

1.4 Equipment Specification

Table 1-2 details the specification of the equipment required to perform a calibration.

Table 1-1: Calibration Equipment Requirements

Equipment	Minimum Specification	Purpose
Pressure Standard (manual or automated)	Range: 27.62 to 3500 mbar Uncertainty: 32 ppm of reading + 0.007 mbar (0.0032 % of reading + 0.7 Pa)	To compare against ADTS.
Computer (optional)	PC equipped with IEEE 488 Interface.	Automate calibration by communication with ADTS and Pressure Standard.

1.5 Media Compatibility

INFORMATION Incorrect use of pressure media seriously affects the measurement accuracy of the ADTS.

Refer to Table 1-2 for the permitted pressure media.

Table 1-2: Media Compatibility

ADTS Pressure Sensor[a]	Permitted Pressure Media
Solartron®	Dry air only.
Druck RPT	Dry air or dry nitrogen.

a. The ADTS pressure sensor type is shown on the LCD display during the power-up self-test sequence.

1.6 Preliminary Operations

Review and become familiar with the whole procedure before beginning calibration process.

Allow at least one hour for the ADTS to thermally stabilize after switching on and before calibration.

Before starting a calibration procedure carry out a leak test, see Section 2

To enable calibration, remove the calibration label and, using a 3 mm AF hexagonal key (Allen key/wrench), turn the captive, calibration screw counter-clockwise until free.

The pressure standard datum level must be the same as the unit datum level. The datum level of the unit is on the front panel.

1.6.1 Pressure Source

The calibration menu prompts a selection of an internal or external pressure source.

The internal pressure source selection uses the ADTS in the control mode with the pressure controllers generating the required pressures for calibration. The required aim value and rate of change of pressure can be entered. A pressure standard connects to the output and measures the generated pressure.

The external pressure source selection uses the ADTS in the measure mode with a pressure standard providing the pressure source.

1.7 Notes on Calibration

- For optimum calibration accuracy, the ADTS should be connected to the pressure standard using metal, PTFE or high density polyethylene hoses to avoid contamination of the internal sensors. This is particularly important when using an EXTERNAL pressure source.
- The ADTS should be allowed one hour to thermally stabilize after power on and before performing any calibration routines.
- The units of pressure measurement for calibration in the following procedures are mbar.
- Calibration values that exceed the range of a channel will be ignored as a calibration value for that channel.
- The [END PS] and the closing of the valve prevents the Ps (static) transducer from receiving an overpressure.

2. Leak Test

2.1 ADTS Leak Test

A leak test should be carried out before a calibration procedure to make sure of the integrity of the ADTS.

1. Allow one hour for the ADTS to thermally stabilize after switching on and before calibration.
2. Select RATE ALT and a rate of 195 mbar/min. Select RATE SPEED and a rate of 335 mbar/min.
3. Select ALT and enter a new aim point of 1000 mbar. Check that the ADTS attains the new aim point. Make sure the pressure is stable and within ± 0.1 mbar of the aim point.
4. Select AIRSPEED and enter an aim point of zero. Check that the ADTS is controlling at the aim point.
5. Enter a new aim point of 1450 mbar. Check that the ADTS attains the new aim point. Make sure the pressure is stable and within ± 0.1 mbar of the aim point.
6. Select RATE ALT and LEAK TEST. Select START TIMER for a 5 minute wait and a 5 minute test. Press F3 to start the test.
7. After 10 minutes, the leak rate must be less than 0.5 mbar/min.
8. Select RATE SPEED, the leak rate must be less than 0.5 mbar/min.
9. Select REGAIN CONTROL. Select ALT and enter a new aim point of 75 mbar abs. Check that the ADTS attains the new aim point. Make sure the pressure is stable and within ± 0.1 mbar of the aim point.
10. Select RATE SPEED and LEAK TEST. Select START TIMER for a 5 minute wait and a 5 minute test. Press F3 to start the test.
11. After 10 minutes, the leak rate must be less than 0.5 mbar/min.
12. Select RATE SPEED, the leak rate must be less than 0.5 mbar/min.
13. After 10 minutes, the leak rate must be less than 0.5 mbar/min.
14. Repeat (3) to (8) with ALT at 30 mbar and AIRSPEED at zero.
15. Select REGAIN CONTROL. Select GO TO GROUND. Check that the ADTS attains an ALT pressure of atmospheric, an AIRSPEED value of zero.
16. Select END OF TEST. The ADTS is now ready for calibration.

2.2 Purge and Leak Test

Connect the ADTS to the calibration standard. Use the ADTS calibration check facility to purge and leak check the ADTS and the calibration standard as follows:

1. Enter the calibration check facility and select the required calibration mode.
2. Apply a vacuum from the calibration pressure source. Maintain for five minutes. Return the pressure to approximately atmospheric pressure using the calibration media. Do not vent to atmosphere. Repeat twice more.
3. Apply a suitable pressure, allow to stabilize and leak test the ADTS and calibration system.

3. PIN Protection

A service PIN (Personal Identification Number) can be entered to prevent unauthorized entry into Calibration or Maintenance Mode.

To change the service PIN:

1. Press 000 when the Main Calibration Menu is displayed:

```
     (CALIBRATION)
F1 Main Calibration
F2 Calibration Check
F3 Rate Calibration
```

2. Enter the new PIN.
3. Enter 0000 to disable PIN protection.

4. Calibration

4.1 Enter Calibration Mode

1. Enter the calibration menu from the measurement or control menu by pressing F1 and F4 together.
2. The service PIN, if enabled protects both calibration and maintenance facilities from unauthorized entry. If the service PIN is disabled, the display shows the main calibration menu. To enable or change the service PIN, press the — key then enter the four digit PIN. Enter 0000 to disable the PIN facility.
3. The date of the last main calibration will be shown for 5 seconds followed by the current date. If the date is correct then press ENTER. If the date is incorrect then enter all 6 digits of the current date. The format is shown as either:

   i. “(MDY)” (mm/dd/yy)

   ii. “(DMY)” (dd/mm/yy)

   Press ENTER to accept the new date.

   Note: “Unknown” will be shown if the last calibration is not known, after a software update for example.
4. The following screen then displays:

```
     (CALIBRATION)
F1 Main Calibration
F2 Calibration Check
F3 Rate Calibration
```

5. Select the type of calibration to be carried out.
6. Select the pressure source:

```
Source
F1 Internal
F2 External
```

7. Select the channel for calibration:

```
F1 Ps Calibration
F2 Pt Calibration
F3 Ps&Pt Calibration
```

8. Carry out the appropriate procedure in the following paragraphs.

4.2 Calibration Check

The procedure for calibration check is identical to the main calibration procedure except that [ACTUAL VALUE] is not available and [END CAL] is replaced by [Ps END] which closes a valve to protect static (Ps). Pressures must be applied in ascending order.

Note: The pitot (Pt) channel is checked in absolute mode, with Auto Zero automatically disabled.

Differential Qc or airspeed accuracy may be checked in normal user mode. For optimum differential accuracy during these tests, auto zero should be ON. This is particularly significant for very low airspeed values.

Note: The tolerance quoted in the following tables may need to be adjusted to allow for measurement uncertainties of the calibration standard in use. The limits stated relate to the

published, minimum specification for the equipment entering service. Acceptance limits may vary at the user's discretion for specific applications.

4.3 Calibration Check of the Static Channel

Before starting this procedure carry out a leak test as detailed in Section 2 Set the unit to measurement mode, calibration check, external pressure source and static (Ps) calibration as detailed in Section 4.1.

1. Connect calibration pressure to the static output.
2. Adjust calibration pressure to the first pressure value in Table 4-1.
3. Compare the pressure value on the calibration standard to the value displayed and record the difference. Press [ENTER] and display prompts for the next pressure value.
4. Repeat (2) and (3) for pressure No. 2 to 8 in Table 4-1.
5. If the recorded difference exceeds the allowable tolerance ([a]) carry out a calibration adjustment detailed in Section 4.7.
6. Select F4 [END]. The display goes back to the channel select menu, select another channel for calibration checking or exit the calibration menu.
7. Adjust calibration standard to atmospheric pressure. Disconnect calibration standard from the static output.
8. If there is no further calibration or testing required, switch off the unit.

Table 4-1: Static Channel Calibration Pressures

Pressure No.	Pressure (mbar)	Tolerance[a] (± mbar)
1	27.62	0.1
2	72.00	0.1
3	189.00	0.1
4	466.00	0.1
5	697.00	0.1
6	843.00	0.1
7	1013.00	0.1
8	1355.00	0.1

a. The tolerance quoted in this table may need to be adjusted to allow for measurement uncertainties of the calibration standard in use. The limits stated relate to the published, minimum specification for the equipment entering service. Acceptance limits may vary at the user's discretion for specific applications.

4.4 Calibration Check of the Pitot Channel

Before starting this procedure carry out a leak test as detailed in Section 2. Set the unit to measurement mode, calibration check, external pressure source and pitot (Pt) calibration as detailed in Section 4.1.

1. Connect calibration standard to the pitot output.
2. Adjust calibration pressure to the first pressure value in Table 4-2.
3. Compare the pressure value on calibration standard to the value displayed and record the difference. Press [ENTER] and display prompts for the next pressure value.
4. Repeat (2) and (3) for pressure No. 2 to 11 in Table 4-2; points 12 to 13 are used on the 1000 knot Pitot range sensor.

Note: A label on the front panel of the ADTS403/405 shows the full-scale range of the Pitot sensor.

5. If the recorded difference exceeds the allowable tolerance ([a]) carry out a calibration adjustment detailed in Section 4.8.
6. Select F4 [END]. The display goes back to the channel select menu, select another channel for calibration checking or exit the calibration menu.
7. Adjust calibration standard to atmospheric pressure. Disconnect calibration standard from the pitot output.
8. If there is no further calibration or testing required, switch off the unit.

Table 4-2: Pitot Channel Calibration Pressures

Pressure No.	Pressure (mbar)	ADTS403/405 Tolerance[a] (± mbar)	ADTS405MK2 850 knot Tolerance[a] (± mbar)	ADTS405MK2 1000 knot Tolerance[a] (± mbar)
1	27.62	0.24	0.20	0.26
2	72.00	0.24	0.20	0.26
3	189.00	0.25	0.20	0.26
4	466.00	0.25	0.20	0.26
5	697.00	0.26	0.20	0.26
6	843.00	0.27	0.20	0.26
7	1013.00	0.27	0.20	0.26
8	1100.00	0.28	0.20	0.26
9	1655.00	0.32	0.20	0.26
10	2200.00	0.36	0.20	0.26
11	2590.00	0.40	0.20	0.26
12	3000.00	0.44[b]	–	0.26
13	3500.00	0.49[b]	–	0.26

a. The tolerance quoted in this table may need to be adjusted to allow for measurement uncertainties of the calibration standard in use. The limits stated relate to the published, minimum specification for the equipment entering service. Acceptance limits may vary at the user's discretion for specific applications.
b. 1000 knot Pitot (Pt) range.

4.5 Calibration Check of the Combined Pitot and Static Channels

Before starting this procedure carry out leak tests as detailed in Section 2. Set the unit to measurement mode, calibration check, external pressure source and static (Ps) and pitot (Pt) calibration as detailed in Section 4.1.

1. Connect calibration standard to the pitot output.
2. Adjust calibration standard to the first pressure value in Table 4-3.
3. Compare the pressure value on calibration standard to the value displayed and record the difference. Press [ENTER] and display prompts for the next pressure value.
4. Repeat (2) and (3) for pressure No. 2 to 8 in Table 4-3.

5. Press F4 [END PS], the unit automatically isolates the static channel from further pressures.

CAUTION **The static channel transducer will be over-pressurized and probably damaged if further pressure in Table 4-3 are applied.**

6. Repeat (2) and (3) for pressure No. 9 to 11 in Table 4-3; points 12 and 13 are used on the 1000 knot Pitot range sensors.

   Note: A label on the front panel of the ADTS403/405 shows the full-scale range of the Pitot sensor.

7. If the recorded difference exceeds the allowable tolerance ([a]) carry out a calibration adjustment detailed in Section 4.9.
8. Press [END] F4.
9. The display goes back to the channel select menu, select a channel for calibration checking or exit the calibration menu.
10. Adjust calibration standard to atmospheric pressure. Disconnect calibration standard from the unit.
11. If there is no further calibration or testing required, switch off the unit.

Table 4-3: Combined Pitot and Static Calibration Pressure

Pressure No.	Pressure (mbar)	Static (Ps) Tolerance[a] (± mbar)	ADTS403/405 Pitot (Pt) Tolerance[a] (± mbar)	ADTS405MK2 850 knot Pitot (Pt) Tolerance[a] (± mbar)	ADTS405MK2 1000 knot Pitot (Pt) Tolerance[a] (± mbar)
1	27.62	0.1	0.24	0.20	0.26
2	72.00	0.1	0.24	0.20	0.26
3	189.00	0.1	0.25	0.20	0.26
4	466.00	0.1	0.25	0.20	0.26
5	697.00	0.1	0.26	0.20	0.26
6	843.00	0.1	0.27	0.20	0.26
7	1013.00	0.1	0.27	0.20	0.26
8	1100.00 [END PS]	0.1	0.28	0.20	0.26
9[b]	1655.00	0.1	0.32	0.20	0.26
10[b]	2200.00	0.1	0.36	0.20	0.26
11[b]	2590.00	0.1	0.40	0.20	0.26
12[b]	3000.00	0.1	0.44[c]	–	0.26
13[b]	3500.00	0.1	0.49[c]	–	0.26

a. The tolerance quoted in this table may need to be adjusted to allow for measurement uncertainties of the calibration standard in use. The limits stated relate to the published, minimum specification for the equipment entering service. Acceptance limits may vary at the user's discretion for specific applications.
b. Pitot only.
c. 1000 knot Pitot (Pt) range.

4.6 Main Calibration

4.6.1 To Operate Calibration Switch

1. Remove the old label.
2. Rotate the screw beneath the label fully counter-clockwise. When calibration is complete, rotate the screw fully clockwise and fit a new calibration label.

4.6.2 Pressure Source

Select the pressure and vacuum source to be used during the calibration.

- Internal:

  This selection uses the pressure and vacuum controllers of the ADTS to generate the required pressures for calibration. The necessary AIM values and RATE of pressure change can be set. A calibration standard of the required accuracy, connected to the output ports, measures the pitot and static channels.

  This is the recommended method of calibration.

- External:

  This selection uses a deadweight tester (or similar calibration standard) to generate the pressure and vacuum for calibration. The ADTS, in measure mode, displays the applied pressure and vacuum in the pitot and static channels.

4.6.3 Select Calibration Mode

Select calibration mode from:

- Static (Ps) channel - absolute

  This mode calibrates the static (Ps) channel.

Connect the calibration standard to the static (Ps) output on the front panel. Fit the blank on the pitot (Pt) output.

- Pitot (Pt) channel - absolute

  This mode calibrates the pitot (Pt) channel, using an absolute pressure, calibration standard.

Connect the calibration standard to the pitot (Pt) output on the front panel.

Fit the blank on the Static (Ps) output.

- Combined Static (Ps) and Pitot (Pt) channel - absolute

  This mode enables combined calibration of static (Ps) and pitot (Pt) channels to minimize calibration time and errors due to calibration standard non-repeatability.

Connect the calibration standard to the pitot (Pt) output on the front panel.

Fit the blank on the Static (Ps) output.

CAUTION Unless the [END CAL] instruction is given, the static PS sensor will be over-pressured with pitot PT values.

When using combined static (Ps) and pitot (Pt) calibration, the pressures must be applied in ascending order starting from the lowest pressure. Each entered exact pressure will be used as a calibration point for both static (Ps) and pitot (Pt) until [END CAL] is selected. At that point the static (Ps) calibration will be completed, a valve will close to protect the static (Ps) channel and the remaining points will be used for the pitot (Pt) channel only.

Calibration Points

1. Following calibration initialization, the calibration entry screen appears, showing the present measured static (Ps) and pitot (Pt) values.

2. Two functions are common to INTERNAL and EXTERNAL pressure source:

[ACTUAL VALUE]

- This allows the actual value of the pressure, applied by or measured by the calibration standard, to be entered. The pressure must be allowed to stabilize before entering the value. The minimum number of calibration points is two.
- There is no upper limit to the number of points that may be entered. For specification accuracies to be achieved, Druck recommend a minimum of five points on static (Ps) with a further three on pitot (Pt) if both are calibrated together.
- If a small number of applied pressures are used for calibration adjustment, it is recommended that the resultant performance is checked at pressures between these points to confirm linear response over the range.

[END CAL]

- This function completes the calibration of the relevant channel. In combined static (Ps) and pitot (Pt) mode, selecting [END CAL] for the first time completes the static (Ps) calibration, selecting [END CAL] for the second time completes the pitot (Pt) calibration.
- When [END CAL] is selected, the required zero and slope corrections are calculated and displayed. These can either be accepted or rejected. If accepted, the calibration will be updated. If rejected, the calibration will not be updated.

CAUTION Unless the [END CAL] instruction is given, the static PS sensor will be over-pressured with pitot PT values.

- A further four functions are available when the INTERNAL pressure source has been selected.

[AIM]

- This allows the next calibration point to be entered.
- Select [AIM] then enter the required pressure using the units shown on the display. The pressure will change towards the new AIM using the rate selected by [RATE].

CAUTION The AIM values are not limit checked. Ensure that the required value is correctly entered.

- If necessary, check the current AIM value by select [AIM]. Press QUIT to return to the calibration screen.

[OFF]

- This switches the pressure controllers OFF to enable leak testing of the system.

[ON]

- This switches the pressure controllers ON again after leak testing.

[RATE]

- This allows the rate of change of pressure to be entered.
- Select [RATE] then enter the required rate of change of pressure using the units shown on the display.

CAUTION The rate values are not limit checked. Make sure that the required rate is correctly entered. High rates of change can damage sensitive equipment.

- If necessary, check the current RATE by selecting [RATE]. Press QUIT to return to the calibration screen.

4.7 Calibration and Adjustment of the Static Channel

Before starting this procedure carry out a leak test as detailed in Section 2. Set the unit to measurement mode, main calibration, external pressure source and static (Ps) calibration as detailed in Section 4.1.

1. Connect calibration standard to the static output.
2. The display prompts for the date of calibration DD/MM/YY.

   Note: The pressure values shown in the table are the values used and suggested by the manufacturer, other values can be used.
3. Adjust calibration standard to the first pressure value in Table 4-1. Allow 1 minute for the unit to stabilize.
4. The display prompts for [ACTUAL VALUE], enter the pressure value on the calibration standard. Press [PRES] and the display prompts for the next pressure value.
5. Repeat (3) and (4) for pressure No. 2 to 8 in Table 4-1.
6. After the last pressure value press [END] F4.
7. The unit calculates the change in zero (%FS) and span (%RD) from the previous, stored calibration values. The new calibration can be accepted or rejected. Once accepted, the new values are stored replacing the previous values.
8. Adjust calibration standard to atmospheric pressure. Using a 3 mm AF hexagonal key (Allen key), turn the captive, calibration screw fully clockwise.
9. To verify the new calibration, carry-out a calibration check of the static channel as detailed in Section 4.1, starting at (2).

   Note: After adjustment, Ps precision against the calibration standard shall be ≤ 0.6 mbar.
10. After completion of all main calibration procedures, carry out the procedures detailed in Section 4.10.

4.8 Calibration and Adjustment of the Pitot Channel

Before starting this procedure carry out a leak test as detailed in Section 2. Set the unit to measurement mode, main calibration, external pressure source and Pt (pitot) calibration as detailed in Section 4.1.

1. Connect calibration standard to the pitot output.
2. The display prompts for the date of calibration DD/MM/YY.

   Note: The pressure values shown in the table are the values used and suggested by the manufacturer, other values can be used.
3. Adjust calibration standard to the first pressure value in Table 4-2. Allow 1 minute for the unit to stabilize.
4. The display prompts for [ACTUAL VALUE], enter the pressure value on the calibration pressure. Press [PRES] and the display prompts for the next pressure value.
5. Repeat (3) and (4) for pressure No. 2 to 11 in Table 4-2; points 12 and 13 are used on the 1000 knot Pitot range sensors.

   Note: A label on the front panel of the ADTS403/405 shows the full-scale range of the Pitot sensor.
6. After the last pressure value press [END] F4.

7. The unit calculates the change in zero (%FS) and span (%RD) from the previous, stored calibration values. The new calibration can be accepted or rejected. Once accepted, the new values are stored replacing the previous values.
8. Adjust calibration standard to atmospheric pressure. Using a 3 mm AF hexagonal key (Allen key), turn the captive, calibration screw fully clockwise.
9. To verify the new calibration, carry-out a calibration check of the pitot channel as detailed in Section 4.4, starting at (2).

   Note: After adjustment, Pt precision against the calibration standard shall be ≤ 0.14 mbar for 850 knot models and ≤ 0.17 mbar for 1000 knot models.
10. After completion of all main calibration procedures, carry out the procedures detailed in Section 4.10.

4.9 Calibration and Adjustment of the Combined Static and Pitot Channels

Before starting this procedure carry out leak tests as detailed in Section 2. Set the unit to measurement mode, main calibration, external pressure source and static (Ps) and pitot (Pt) calibration as detailed in Section 4.1.

1. Connect calibration standard to the pitot output.
2. The display prompts for the date of calibration DD/MM/YY.

   Note: The pressure values shown in the table are the values used and suggested by the manufacturer, other values can be used.
3. Adjust calibration standard to the first pressure value in Table 4-3. Allow 1 minute for the unit to stabilize.
4. The display prompts for [ACTUAL VALUE], enter the pressure value on the calibration standard. Press [PRES] and the display prompts for the next pressure value.
5. Repeat (3) and (4) for pressure No. 2 to 8 in Table 4-3.
6. Press F4 [END PS], the unit automatically isolates the static channel from further pressures. The unit calculates the change in zero (%FS) and span (%RD) from the previous, stored static channel calibration values. The new calibration can be accepted or rejected. Once accepted, the new values are stored replacing the previous values.

CAUTION The static channel transducer will be over-pressurized and probably damaged if further pressures in Table 4-3 are applied.

7. Repeat (3) and (4) for pressure No. 9 to 11 in Table 4-3; points 12 and 13 are used on the 1000 knot Pitot range sensors.

   Note: A label on the front panel of the ADTS403/405 shows the full-scale range of the Pitot sensor.
8. Press F4 [END]. The unit calculates the change in zero (%FS) and span (%RD) from the previous, stored pitot channel calibration values. The new calibration can be accepted or rejected. Once accepted, the new values are stored replacing the previous values.
9. Adjust calibration standard to atmospheric pressure. Using a 3 mm AF hexagonal key (Allen key), turn the captive, calibration screw fully clockwise.
10. To verify the new calibration, carry-out a calibration check of the combined pitot and static channels as detailed in Section 4.5, starting at (2).

    Note: After adjustment, Ps precision against the calibration standard shall be ≤ 0.6 mbar, Pt precision shall be ≤ 0.14 mbar for 850 knot models and ≤ 0.17 mbar for 1000 knot models.

11. Before leaving Calibration mode, the ADTS prompts to “Back up New Calibration Data?”. Answering ‘YES’ will back up the calibration data, for both controllers, in the motherboard. After completion of all main calibration procedures, carry out the procedures detailed in Section 4.10.

4.10 Completion

After completion of all main calibration procedures, carry out the following:

1. Make sure the calibration standard and the unit are at atmospheric pressure. Disconnect the calibration standard from the unit.
2. Fit a new calibration label over the calibration screw.

4.11 Rate Calibration

Rate calibration should only be carried out if the rate accuracy is suspect. The accuracy of measurement and control is not affected by a rate calibration and the calibration date does not change after using this facility.

Note: For the rate calibration to be performed, pressure and vacuum supplies need to be connected and the static (Ps) and pitot (Pt) outlets blanked.

To perform a rate calibration:

1. Select [RATE CAL] and the unit automatically carries out a rate calibration. The display shows “Rate calibration please wait” message for approximately two minutes.
2. Press the QUIT key exit this menu and return to control mode.

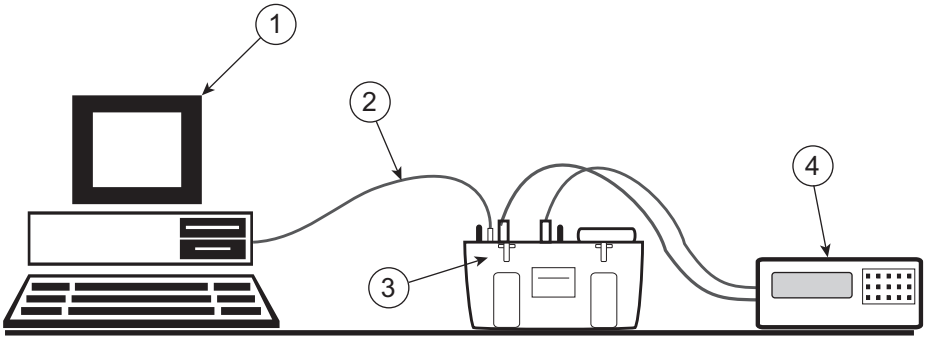
5. Calibration using IEEE 488 SCPI

The IEEE 488 facility requires specialist knowledge of both IEEE 488 communications and programming for specified, authorized calibration procedures. Only qualified personnel should use this facility.

5.1 Automatic Calibration

INFORMATION **Incorrect recalculation of residual error correction values seriously affects the measurement accuracy of the ADTS. Only qualified personnel must write calibration programs and the resulting calibration accuracies must be verified before using the ADTS on equipment or aircraft systems.**

Calibration using IEEE 488 SCPI follows the same procedure as manual calibration detailed in Section 4 The SCPI commands required for automatic calibration are in the sub-set of the CALibration: command. The Druck ADTS403/405 SCPI Option User Manual, K0157 details each command used in this procedure.



1 Personal computer
2 IEEE 488 connection
3 ADTS405MK2F
4 Pressure standard

Figure 5-1: Automatic Calibration Arrangement

5.1.1 Offset, Slope and Curve Fit Adjustment

The SCPI command CALibration:ADJ causes the ADTS403/405 to return the current values of slope (span), offset (zero) and residual corrections (curve fit). The slope (span), offset (zero) values can then, if necessary, be adjusted and sent back and stored by the ADTS403/405. The curve fit can be adjusted by modifying the 12 residual correction values. The whole process can be automated with a computer program as described in the following.

5.1.2 Computer Algorithm for Offset, Slope and Curve Fit Adjustment

The calibration pressures used should ideally be the given values, shown in the following tables. A permissible tolerance of ± 2 mbar can be entered providing the exact pressures are entered in

the calculations. The required table of values depends on the control channel to be calibrated and, for the pitot channel, the range of the sensor fitted.

Table 5-1: Calibration Pressure Ranges

Port	Pressure Range		Sensor Nominal Full Scale		Table of Applied Pressures
	inHg	mbar	inHg	mbar	
Static	40	1355	38.7	1310	Table 5-3
Pitot 850 knots	80	2700	77.4	2620	Table 5-4
Pitot 1000 knots	103	3500	101.9	3450	Table 5-5

Each calibration pressure has an associated residual error correction value stored in the ADTS. This procedure is invalid if alternative calibration pressures (> ± 2 mbar of the given values) are used because the residual corrections would no longer apply to the expected span point. If any of the pressure points are missed, then the corresponding residual must be set to an assumed value of zero.

The number of calibration points used is referred to as NUMPTS, a maximum of 12 points are listed in the tables, this is so that all of the residual coefficients used in the ADTS403/405 may be calculated. The first calibration point is always zero, it is not necessary to apply it. The residual error for this calibration point will be automatically set to zero as the error, at this point, is best corrected by offset adjustment.

5.2 Defining Elements for a Program

5.2.1 Terms, Variables and Constants

The following terms, variables and constants are used in this section:

Table 5-2: Terms, Variables and Constants

Item	Description
STANDARD_PRESSURE	Pressure measured or applied by the calibration standard (e.g., dead weight)
STANDARD_PRESSURE(n)	Array of standard pressures, indexed by n, in mbar.
AVE403/405(n)	Array of average pressures read from ADTS403/405, in mbar.
OLDSLOPE	Existing slope (span) value.
OLDOFFSET	Existing offset (zero) value, in mbar.
R(0) to R(11)	Residual values in PPM FS.
NUMPTS	Number of calibration points (Max = 11).
MAXPTS	Maximum number of points, set to 11.
PTSUSED	Actual number of calibration pressures applied.
MAXSLOPE	Maximum allowable slope change in % of reading (specified by user).
MAXOFFSET	Maximum allowable offset change in mbar (specified by user).
FS	Sensor full-scale taken from Table 5-1.
M	Change in slope.
C	Change in offset.

The elements to be used in the program are found or calculated in the following:

- To find existing calibration data.
- To find pressure errors between the standard and the ADTS403/405.
- To decide if correction should be carried out.
- To carry out corrections.
- To calculate slope and offset shifts.
- To accept new slope and offset.
- To calculate new residual correction values.
- To install new calibration data.

5.2.2 To Find Existing Calibration Data

Use SCPI CAL:ADJ query command to retrieve slope, offset and residual values into OLDSLOPE, OLDOFFSET and R(0) to R(11).

To initialize variables:

1. FOR n = 1 to MAXPTS
2. STANDARD_PRESSURE(n) = 0
3. AVE403/405(n) = 0

For any calibration point not being used:

1. R(n) = 0
2. NEXT N

5.2.3 To Find Pressure Errors Between Standard and ADTS403/405

1. FOR n = 1 to MAXPTS
2. Apply calibration pressure (value from appropriate table)
3. Store exact value from calibration standard in STANDARD_PRESSURE(n)
4. Take 5 pressure readings from ADTS403/405.
5. Average the five readings.
6. Store averaged readings in AVE403/405(n).
7. NEXT N

If necessary, pressure points may be missed out, see Section 5.1.2. The actual number of points applied should be saved in PTSUSED.

5.2.4 To Decide if Correction Should be Carried Out

If all pressure readings are within specification THEN Exit algorithm here (calibration check complete).

5.2.4.1 To Carry Out Correction

1. SX = 0
2. SX2 = 0
3. SY = 0
4. SY2 = 0
5. FOR n = 1 to MAXPTS
6. COMP403/405(n) = AVE403/405 (n) + (R(n) * FS/1E6)/OLDSLOPE
7. SX = SX + STANDARD_PRESSURE(n)
8. SX2 = SX2 + (STANDARD_PRESSURE(n) * STANDARD_PRESSURE(n))
9. SY = SY + COMP405(n)

10. SXY = SXY + (COMP403/405(n) * STANDARD_PRESSURE(n))

To calculate slope and offset shifts:

1. $$M = \frac{(PTSUSED \times SXY) - (SX \times SY)}{(PTSUSED \times SX2) - (SX \times SX)}$$

2. $$C = \frac{OLDSLOPE \times [SY - (M \times SX)]}{N}$$

5.2.4.2 To Accept New Slope and Offset

1. IF ABS(100 * (M - 1)) < MAXSLOPE
   AND ABS(C) < MAXOFFSET
   THEN
   NEWSLOPE = OLDSLOPE * M
   NEWOFFSET = OLDOFFSET + C

5.2.4.3 To Calculate New Residual Correction Values

1. FOR n = 1 to MAXPTS

2. $$ERR = \left(\frac{COMP403/405(n) - C}{M}\right) - STANDARD\_PRESSURE(n)$$

3. $$ERR = \frac{ERR \times 1 \times 10^{6}}{FS}$$

4. $$R(n) = ERR$$

5. NEXT(n)
6. R(0) = 0, all other missed residuals set to 0.

5.2.4.4 To Install New Calibration Data

Send NEWSLOPE, NEWOFFSET and R(0) to R(11) to ADTS403/405 using CAL:ADJ command.

5.3 Calibration Pressures

Table 5-3: Static Range Calibration Pressures

Point	Calibration Pressure	
	inHg	mbar
0	0.0	0
1	1.0	34
2	3.1	105
3	5.1	173
4	7.1	240
5	10.2	345
6	15.3	518
7	20.4	691
8	25.4	860
9	30.5	1033
10	34.5	1172
11	40.0	1355

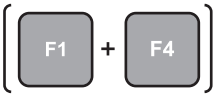
Table 5-4: Pitot - 850 knot Range Calibration Pressures

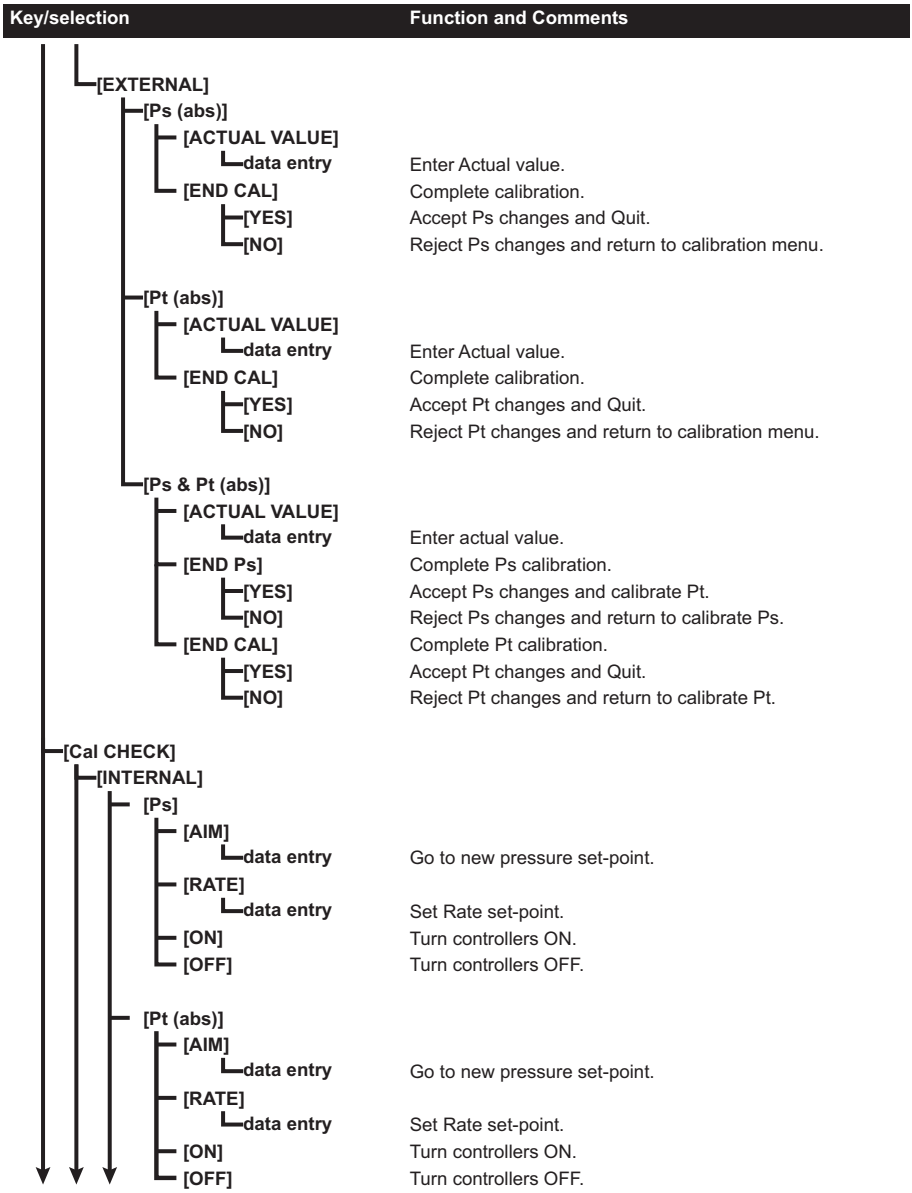
Point	Calibration Pressure	
	inHg	mbar
0	0.0	0
1	1.0	34
2	5.1	173
3	10.2	345
4	15.3	518
5	20.4	691
6	25.4	860
7	30.5	1033
8	38.7	1311
9	50.9	1724
10	63.1	2137
11	80.0	2709

Table 5-5: Pitot - 1000 knot Range Calibration Pressures

Point	Calibration Pressure	
	inHg	mbar
0	0.0	0
1	1.0	34
2	5.1	173
3	10.2	345
4	20.4	691
5	30.5	1033
6	38.7	1311
7	50.9	1724
8	63.1	2137
9	77.4	2621
10	89.6	3034
11	103.3	3500

Appendix A. Quick Reference

Key/selection	Function and Comments
	Enters the calibration menu. Type PIN and check date.
[MAIN CAL]	
[INTERNAL]	
[Ps (abs)]	
[AIM]	
data entry	Go to new pressure set-point.
[RATE]	
data entry	Set Rate set-point.
[ACTUAL VALUE]	
data entry	Enter actual pressure value.
[END CAL]	Complete calibration.
[YES]	Accept changes and Quit.
[NO]	Reject changes and return to calibration menu.
[Ps (abs)]	
[AIM]	
data entry	Go to new pressure set-point.
[RATE]	
data entry	Set Rate set-point.
[ACTUAL VALUE]	
data entry	Enter Actual pressure value.
[END CAL]	Complete calibration.
[YES]	Accept changes and Quit.
[NO]	Reject changes and return to calibration menu.
[Ps & Pt (abs)]	
[AIM]	
data entry	Go to new pressure set-point.
[RATE]	
data entry	Set Rate set-point.
[ACTUAL VALUE]	
data entry	Enter Actual pressure value.
[END Ps]	Complete Ps calibration.
[YES]	Accept Ps changes and calibrate Pt.
[NO]	Reject Ps changes and return to calibrate Ps.
[END CAL]	Complete Pt calibration.
[YES]	Accept Pt changes and Quit.
[NO]	Reject Pt changes and return to Pt calibration.



Key/selection	Function and Comments
[Ps & Pt (abs)]	
[AIM]	
data entry	Go to new pressure set-point.
[RATE]	
data entry	Set Rate set-point.
[OFF]	Turn controllers OFF.
[ON]	Turn controllers ON.
[END Ps]	Exit Ps check, continue with Pt check.
[EXTERNAL]	
[Ps]	
[AIM]	
data entry	Go to new pressure set-point.
[RATE]	
data entry	Set Rate set-point.
[ON]	Turn controllers ON.
[OFF]	Turn controllers OFF.
[Pt (abs)]	
[AIM]	
data entry	Go to new pressure set-point.
[RATE]	
data entry	Set Rate set-point.
[ON]	Turn controllers ON.
[OFF]	Turn controllers OFF.
[Ps & Pt (abs)]	
[AIM]	
data entry	Go to new pressure set-point.
[RATE]	
data entry	Set Rate set-point.
[ON]	Turn controllers OFF.
[OFF]	Turn controllers ON.
[END Ps]	Exit Ps check, continue with Pt check.
[RATE CALIBRATION]	
[000]	
data entry	Set Service (Calibration) PIN.

Appendix A. Quick Reference

Office Locations

https://druck.com/contact

Services and Support Locations

https://druck.com/service