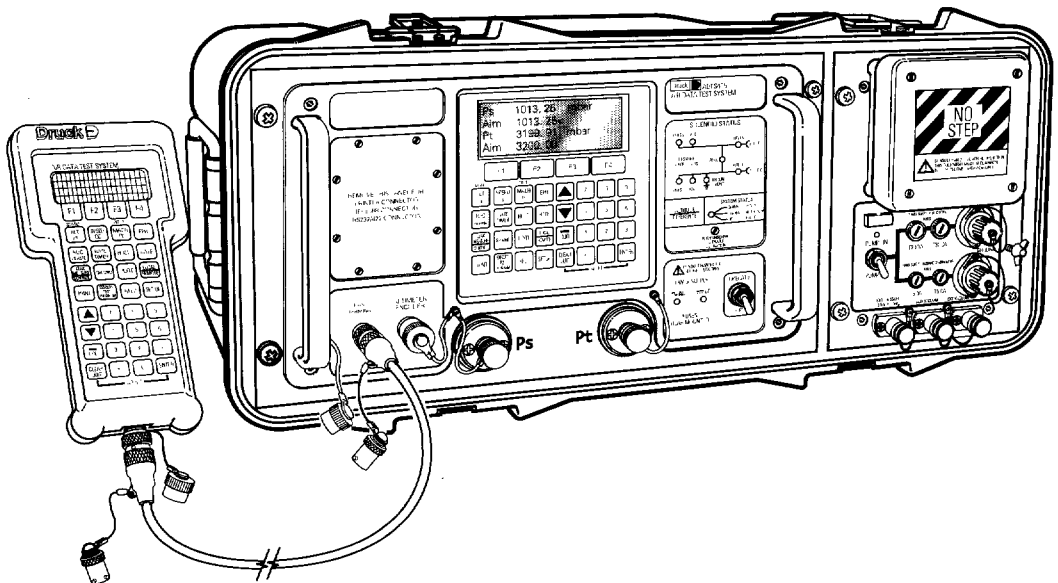
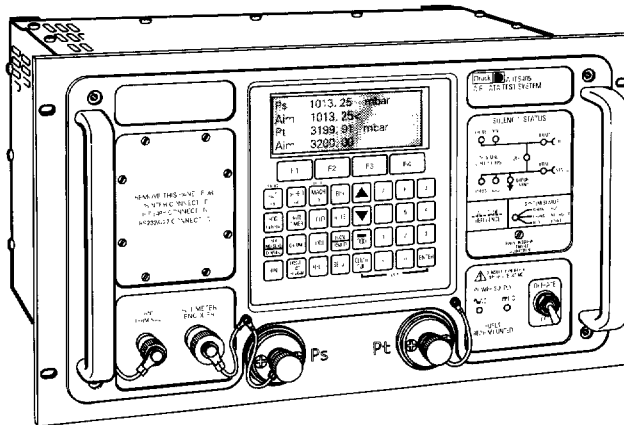


ADTS 405/405F

AIR DATA TEST SYSTEM

Calibration Manual



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Introduction

This technical manual provides calibration instructions for the Druck ADTS 405 Air Data Test System.

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+.

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 ensure 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* personnel and good engineering practice for all procedures in this publication.

Pressure

Do not apply pressure greater 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 authorised service agents or the manufacturer's service departments.

Technical Advice

For technical advice contact the manufacturer or subsidiary.

- * *A qualified person must have attended a product training course given by the manufacturer or appointed agent and successfully completed the training course for this product. For procedures in section 5 (Calibration using the IEEE 488 interface) a qualified person must be trained and qualified in both IEEE 488 communications and test programming.*

Associated Druck Documents:

- K114 ADTS 405 User Manual
- K242 ADTS 405 Operators Manual (Military) [software version 4.20 to 4.29]
- K243 ADTS 405 Operators Manual (Military) [software version 4.31 to 4.39]
- K154 ADTS 405 IEEE 488 Option User Manual
- K157 ADTS 405 SCPI User Manual

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Glossary

Terminology

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

<u>Adjust</u>	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.
<u>Align</u>	To bring into line; to line up; to bring into precise adjustment, correct relative position or coincidence.
<u>Assemble</u> :	To fit and secure together the several parts of; to make or form by combining parts.
<u>Calibrate</u> :	To determine accuracy, deviation or variation by special measurement or by comparison with a standard.
<u>Check</u> :	Make a comparison of a measure of time, pressure, temperature, resistance, dimension or other quality with a known figure for that measurement.
<u>Disconnect</u> :	To detach the connection between; to separate keyed or matched equipment parts.
<u>Dismantle</u> :	To take apart to the level of the next smaller unit or down to all removable parts.
<u>Examine</u> :	To perform a critical visual observation or check for specific conditions; to test the condition of.
<u>Fit</u> :	Correctly attach one item to another.
<u>Inspect</u> :	Review the work carried out by Specialists to ensure it has been performed satisfactorily.
<u>Install</u> :	To perform operations necessary to properly fit an equipment unit into the next larger assembly or system.
<u>Maintain</u> :	To hold or keep in any particular state or condition especially in a state of efficiency or validity.
<u>Make sure</u> :	To confirm that a proper condition exists; to find out with certainty.
<u>Operate</u> :	Ensure that an item or system functions correctly as far as possible without the use of test equipment or reference to measurement.
<u>Readjust</u> :	To adjust again; to move back to a specified condition; to bring back to an in-tolerance condition.

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1 INTRODUCTION

The ADTS 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 system to stay accurate, a calibration check should be carried out at chosen intervals. If the accuracy of the system is not within the specification, carry out a main calibration.

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.

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.

Abbreviations

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

A	Ampere
abs	Absolute
AC	Alternating current
ADTS	Air data test system
ALT	Altitude
ARINC	Aeronautical Radio Incorporated
ASCI	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 ₂ O ₄	Inches of water at 4°C
inH ₂ O ₂₀	Inches of water at 20°C
kg	Kilogram
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

1.1 Calibration Description

● Calibration Check

- This is used to check the calibration without adjusting it. It may be used either to see if the system 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 channel | - | 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 ADTS 405 as the pressure source or by using a pressure standard as the pressure source. The recommended method is to use the air data test system as the pressure source as this is the normal mode of operation of the equipment.

● Main Calibration

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

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

● 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.

1.2 Preliminary Operations

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

Allow at least one hour for the system 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), 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.

- 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.

2 Leak Test

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

- (1) Allow one hour for the system 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 system 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 system is controlling at the aim point.
- (5) Enter a new aim point of 1450 mbar. Check that the system 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 system 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 system attains an ALT pressure of atmospheric, an AIRSPEED value of zero.
- (16) Select END OF TEST. The air data test system is now ready for calibration.

Pressure source

- The calibration menu prompts a selection of an internal or external pressure source.
- The internal pressure source selection uses the air data test system 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 air data test system in the measure mode with a pressure standard providing the pressure source.

Notes:

- (1) *The [END PS] and the closing of the valve prevents the Ps (static) transducer from receiving an over-pressure.*
- (2) *The units of pressure measurement for calibration in the following procedures are mbar.*
- (3) *Calibration values that exceed the range of a channel will be ignored as a calibration value for that channel.*

Notes on calibration

- For optimum calibration accuracy, the air data test system 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 air data test system should be allowed one hour to thermally stabilise after power on and before performing any calibration routines.

Use the calibration check facility to purge and leak check the air data test system and calibration standard as follows:

- Enter the calibration check facility and select the required calibration mode.
- Apply a vacuum from the calibration pressure source. Maintain for five minutes. Return the pressure to approximately atmospheric pressure using the calibration media (dry air). (Do not vent to atmosphere). Repeat twice more.
- Apply a suitable pressure, allow to stabilise and leak test the system and calibration system.

3 PIN Protection

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

To change the service PIN:

- Press 000 when the Main Calibration Menu is displayed:

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

- Enter the new PIN.
- Enter 0000 to disable PIN protection.

4 Calibration

4.1 Enter Calibration Mode

- Enter the calibration menu from the measurement or control menu by pressing F1 and F4 together.
- 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.
- 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 "(MDY)" (mm/dd/yy) or "(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.

- The following screen then displays:

(CALIBRATION)		
F1	-	Main calibration
F2	-	Calibration check
F3	-	Rate calibration

- Select the type of calibration to be carried out

Select the pressure source:

Source		
F1	-	Internal
F2	-	External

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 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 (*) 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* \pm 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

* 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.

Select the channel for calibration:

F1 Ps calibration
F2 Pt calibration
F4 Ps & Pt, calibration

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.*

Table 4-2 Pitot Channel Calibration Pressures

Pressure No	Pressure mbar	Tolerance* ± mbar
1	27.62	0.24
2	72.00	0.24
3	189.00	0.25
4	466.00	0.25
5	697.00	0.26
6	843.00	0.27
7	1013.00	0.27
8	1100.00	0.28
9	1655.00	0.32
10	2200.00	0.36
11	2590.00	0.40
12	3000.00	0.44†
13	3500.00	0.49†

† 1000 knot Pitot (Pt) range

- * 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 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 ADTS 405 shows the full-scale range of the Pitot sensor.*

- (5) If the recorded difference exceeds the allowable tolerance (*) 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 4-3 Combined Pitot and Static Calibration Pressures

Pressure number	Pressure mbar	Tolerance* ± mbar	Tolerance* ± mbar
		Static (Ps)	Pitot (Pt)
1	27.62	0.1	0.24
2	72.00	0.1	0.24
3	189.00	0.1	0.25
4	466.00	0.1	0.25
5	697.00	0.1	0.26
6	843.00	0.1	0.27
7	1013.00	0.1	0.27
8	1100.00 [END PS]	0.1	0.28
9 (Pitot only)	1655.00	0.1	0.32
10 (Pitot only)	2200.00	0.1	0.36
11 (Pitot only)	2590.00	0.1	0.40
12 (Pitot only)	3000.00	0.1	0.46†
13 (Pitot only)	3500.00	0.1	0.49†

† 1000 knot Pitot (Pt) range

* 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.

4.5 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 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 ADTS 405 shows the full-scale range of the Pitot sensor.*

- (7) If the recorded difference exceeds the allowable tolerance (*) 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.

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 pitot (Pt) 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.

4.6 Main Calibration

▣ To operate switch:

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

▣ 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 air data test system 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 air data test system, in measure mode, displays the applied pressure and vacuum in the pitot and static channels.

[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.

Calibration Points

- Following calibration initialisation, the calibration entry screen appears, showing the present measured static (Ps) and pitot (Pt) values.
- 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 stabilise 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.

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 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 ADTS 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 4.4, starting at (2).

- (10) After completion of all main calibration procedures, carry out the procedures detailed in 4.9.

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 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 (2) and (3) 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 3 ARE APPLIED.**

- (7) 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 ADTS 405 shows the full-scale range of the Pitot sensor.*

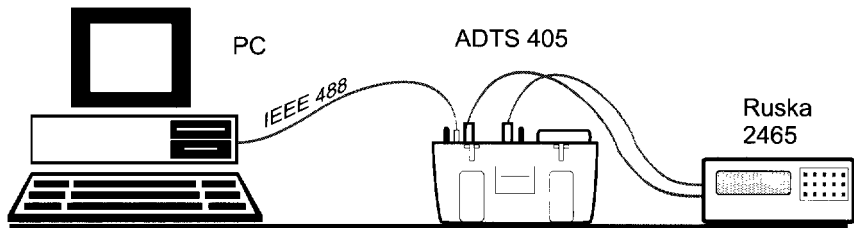
- (8) Press F4 [END]. The unit calculates the change in zero (%FS) and span (%RD) from the previous, stored pitot channel calibration values. The new calibration can be accepted or rejected. Once accepted, the new values are stored replacing the previous values.
- (9) Adjust calibration standard to atmospheric 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 4.5 starting at (2).

5 Calibration using IEEE 488 SCPI

This 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

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 ADTS 405 SCPI Option User Manual, K157 details each command used in this procedure.



Automatic Calibration Arrangement

IMPORTANT NOTE

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

Offset, Slope and Curve Fit Adjustment

The SCPI command **CALibration:ADJ** causes the ADTS 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 ADTS 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.

Computer Algorithm for Offset, Slope and Curve Fit Adjustment

General (Table 5-1)

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.

Static (Ps) Range		Sensor nominal full-scale (FS)		Table of applied pressures
inHg	mbar	inHg	mbar	
40	1355	38.7	1310	5-2
Pitot (Pt) Range				
80	2700	77.4	2620	5-3
103	3500	101.9	3450	5-4

Table 5-1 Calibration Pressure Ranges

Each calibration pressure has an associated residual error correction value stored in the system. This procedure is invalid if alternative calibration pressures ($> \pm 2$ 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 ADTS 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

Terms, Variables and Constants

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

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
AVE405(n)	Array of average pressures read from ADTS 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 ADTS 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.

- **To find existing calibration data**

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

To initialise variables:

```
FOR n      = 1 to MAXPTS
STANDARD_PRESSURE(n) = 0
AVE405(n)   = 0
```

For any calibration point not being used:

```
R(n) = 0
NEXT N
```

- **To find pressure errors between standard and ADTS 405**

```
FOR n = 1 to MAXPTS
```

```
    Apply calibration pressure (value from appropriate table)
    Store exact value from calibration standard in STANDARD_PRESSURE(n)
    Take 5 pressure readings from ADTS 405
    Average the five readings
    Store averaged readings in AVE405(n)
NEXT N
```

If necessary, pressure points may be missed out, see 5-1. The actual number of points applied should be saved in PTSUSED.

- **To decide if correction should be carried out**

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

- **To carry out correction**

SX = 0

SX2 = 0

SY = 0

SY2 = 0

```
FOR n      = 1 to MAXPTS
COMP405(n) = AVE405 (n) + (R(n) * FS/1E6)/OLDSLOPE
SX  = SX + STANDARD_PRESSURE(n)
SX2 = SX2 + (STANDARD_PRESSURE(n) * STANDARD_PRESSURE(n))
SY  = SY + COMP405(n)
SXY = SXY + (COMP405(n) * STANDARD_PRESSURE(n))
NEXT N
```

- **To calculate slope and offset shifts**

$$M = \frac{(PTSUSED * SXY) - (SX * SY)}{(PTSUSED * SX2) - (SX * SX)}$$

$$C = \frac{OLDSLOPE * (SY - (M * SX))}{N}$$

- **To accept new slope and offset**

```
IF ABS(100 * (M - 1)) < MAXSLOPE
AND ABS(C) < MAXOFFSET
THEN
```

NEWSLOPE = OLDSLOPE * M

NEWOFFSET = OLDOFFSET + C

- **To calculate new residual correction values**

FOR n = 1 to MAXPTS

$$ERR = \frac{COMP405(n) - C}{M} - STANDARDPRESSURE(n)$$

$$ERR = \frac{ERR * 1E6}{FS}$$

$$R(n) = ERR$$

NEXT(n)

R(0) = 0, all other missed residuals set to 0

- **To install new calibration data**

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

Point	Calibration pressure	
	inHg	mbar
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	1355

Table 5-2 Static Range Calibration Pressures

Point	Calibration pressure	
	inHg	mbar
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	2709

Table 5-3 Pitot - 850 knot Range Calibration Pressures

Point	Calibration pressure	
	inHg	mbar
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

Table 5-4 Pitot - 1000 knot Range Calibration Pressures

[F1 & F4]

[MAIN CAL]

[INTERNAL]

[Ps (abs)]

[AIM]

└ Data Entry

[RATE]

└ Data Entry

[ACTUAL VALUE]

└ Data Entry

[END CAL]

└ [YES]

└ [NO]

- Type PIN and check date

- Go to new pressure set-point

- Set RATE set-point

- Enter Actual pressure value

- Complete calibration

- Accept changes and Quit

- Reject changes and return to Cal.

[Pt (abs)]

[AIM]

└ Data Entry

[RATE]

└ Data Entry

[ACTUAL VALUE]

└ Data Entry

[END CAL]

└ [YES]

└ [NO]

- Go to new pressure set-point

- Set RATE set-point

- Enter Actual pressure value

- Complete calibration

- Accept changes and Quit

- Reject changes and return to Cal.

[Ps & Pt (abs)]

[AIM]

└ Data Entry

[RATE]

└ Data Entry

[ACTUAL VALUE]

└ Data Entry

[END Ps]

[YES]

[NO]

[END CAL]

[YES]

[NO]

- Go to new pressure set-point

- Set RATE set-point

- Enter Actual pressure value

- Complete Ps Calibration

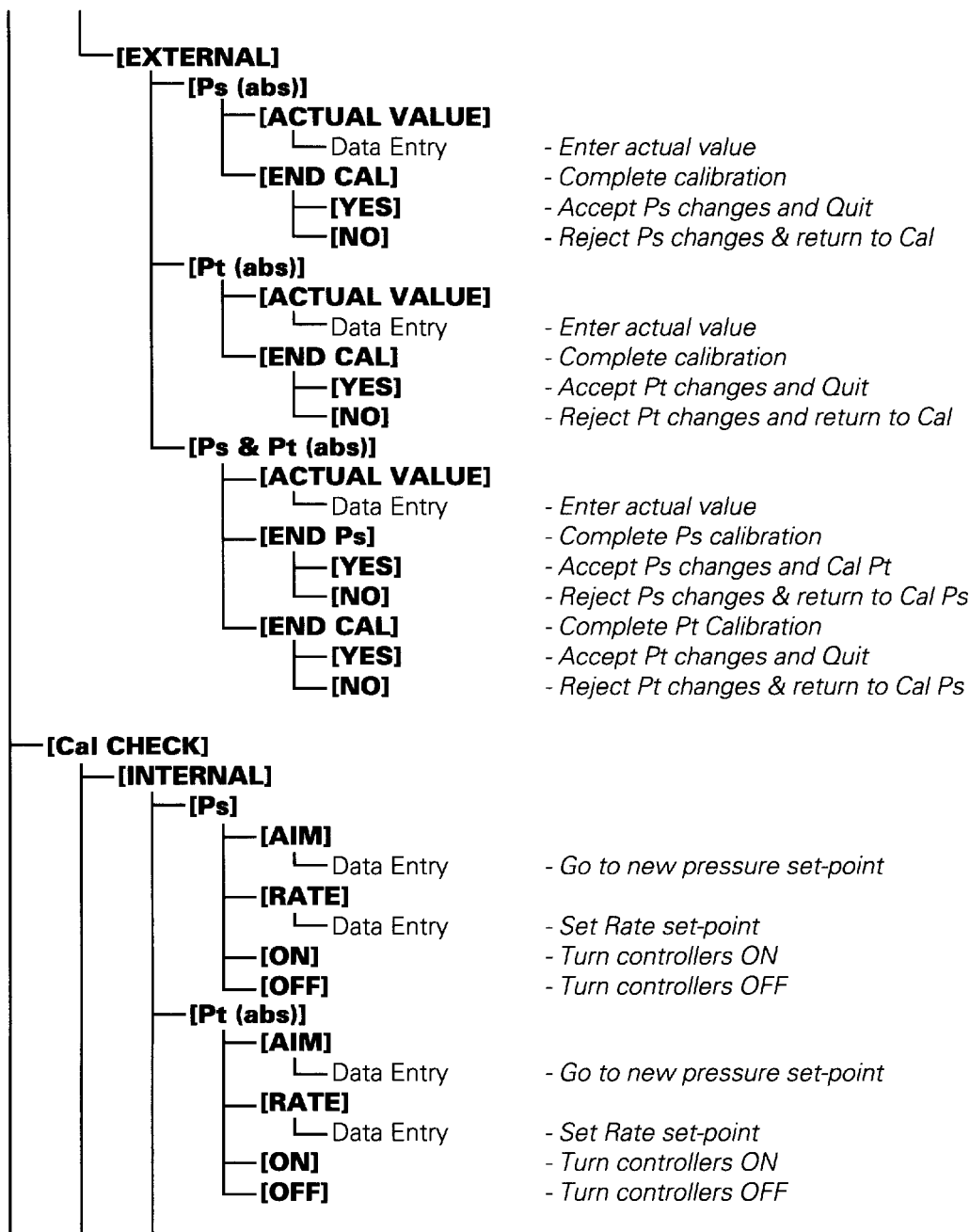
- Accept Ps changes and Cal Pt

- Reject Ps changes & return to Cal Ps

- Complete Pt calibration

- Accept Pt changes and Quit

- Reject Pt changes & return to Pt Cal.



- Enter actual value
- Complete calibration
- Accept Ps changes and Quit
- Reject Ps changes & return to Cal
- Enter actual value
- Complete calibration
- Accept Pt changes and Quit
- Reject Pt changes and return to Cal
- Enter actual value
- Complete Ps calibration
- Accept Ps changes and Cal Pt
- Reject Ps changes & return to Cal Ps
- Complete Pt Calibration
- Accept Pt changes and Quit
- Reject Pt changes & return to Cal Ps

