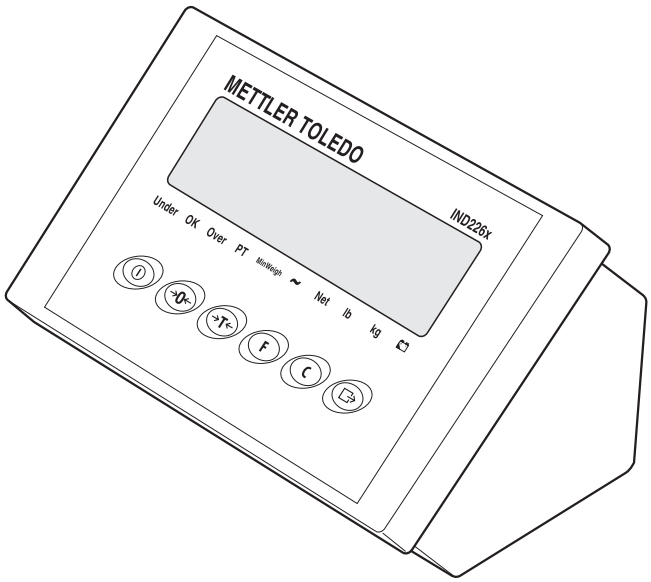
Service Manual

METTLER TOLEDO MultiRange IND226x weighing terminal



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Contents

1 Safety instructions

The IND226x weighing terminal is approved for operation in Zone 1 and 21 hazardous areas. The interface converter ACM200 may only be installed and operated in the safe area.
Particular care is required when using weighing systems with the IND226x weighing terminal in hazardous areas. The code of practice is oriented to the "Safe Distribution" concept drawn up by METTLER TOLEDO.

Competence

▲ The weighing system may only be installed, maintained and repaired by authorized METTLER TOLEDO service personnel.

Ex approval

▲ No modifications may be made to the terminal and no repair work may be performed on the modules. Any weighing platform or system modules that are used must comply with the specifications contained in the installation instructions. Non-compliant equipment jeopardizes the intrinsic safety of the system, cancels the "Ex" approval and renders any warranty or product liability claims null and void.

▲ The safety of the weighing system is only guaranteed when the weighing system is operated, installed and maintained in accordance with the respective instructions.

▲ Also comply with the following:
- the instructions for the system modules
- the regulations and standards in the respective country
- the statutory requirement for electrical equipment installed in hazardous areas in the respective country
- all instructions related to safety issued by the owner

▲ The explosion-protected weighing system must be checked to ensure compliance with the requirements for safety before being put into service for the first time, following any service work and every 3 years, at least.

Operation

▲ Prevent the build-up of static electricity. Always wear suitable working clothes when operating or performing service work in a hazardous area.

▲ Do not use protective coverings for the devices.

▲ Protect the keyboard membrane of the weighing terminal against ultraviolet radiation.

▲ Avoid damage to the system components.

Installation

▲ Only install or perform maintenance work on the weighing terminal in the hazardous zone if the following conditions are fulfilled:

- if the intrinsically safe characteristic values and zone approval of the individual components are in accord with one another,
- the owner has issued a permit ("spark permit" or "fire permit"),
- the area has been rendered safe and the owner's safety co-ordinator has confirmed that there is no danger,
- the necessary tools and any required protective clothing are provided (danger of the build-up of static electricity).

▲ The certification papers (conformity certificates, manufacturer's declarations) must be present.

▲ Use only cables for intrinsically-safe circuits in accordance with the applicable country-specific regulations and standards for the installation of a weighing system with the IND226x weighing terminal.

▲ Lay cables in such a way that they are protected from damage.

▲ Only route cables into the housing of the system modules via an approved, suitable earthing cable gland and ensure proper seating of the seals.

▲ If the weighing terminal is used in conjunction with an automatic or manual filling plant, all of the system modules must be equipped with a permanently wired emergency stop circuit, independent of the system circuit, in order to prevent personal injury or damage to other items of equipment.

Maintenance

▲ Always disconnect the system from the power supply before commencing maintenance work. Where certain inspections, tests or adjustments require the system to remain connected to the power supply, this work must be performed with particular care.

Service

▲ Service technicians must have attended a product-specific course of training for hazardous-duty equipment.

▲ Service work should be performed outside hazardous zones wherever possible. Service work includes dismantling an "Ex" device inside the hazardous area and moving it into the safe area.

▲ To avoid accident and injury, turn the weighing terminal off and wait for at least 30 seconds before connecting or disconnecting cables to/from the printed circuit board.

▲ Only use the parts or modules specified in the spare parts list as replacements.

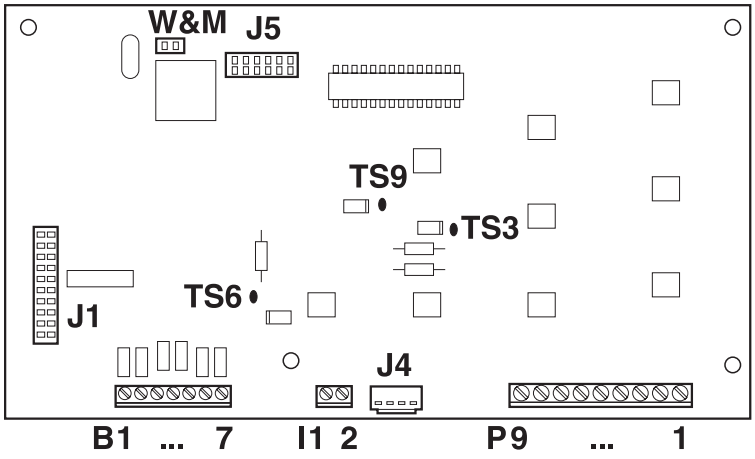
2 Troubleshooting

2.1 Operating errors

Operating errors at the terminal and operating conditions of the weighing platform which lead to inadmissible or impossible weight determination are displayed by the terminal in the form of error codes.

2.2 Checking voltages on the IND226x

Note
To check the voltages on the IND226x mainboard, the keyboard must be connected and the terminal switched on.



Socket	Connection
B 1...7	Scale connection
I 1, 2	Active input
J1	Keyboard connection
J4	Serial data interface
J5	Reserved
P 1...9	Power supply connection

2.2.1 Checking input voltages on the IND226x

Power supply unit	Measuring point	Setpoint [V DC]
APS500/APS501	P1–P2	7.6 ... 11.76 V
Battery Pack	P1–P2	7.6 ... 12.00 V
PSUx	P1–P2 P3–P2 P6–P2	7.6 ... 12.60 V 7.6 ... 12.60 V 7.6 ... 12.60 V

2.2.2 Checking internal voltages of the function modules of the IND226x

Voltage	Measuring point	Setpoint [V DC]
3.3 V supply (microcontroller)	TS3–P2	3.2 ... 3.4 V
5 V analog (A/D converter)	TS6–P2	4.9 ... 5.1 V
5 V digital (display)	TS9–P2	4.9 ... 5.1 V

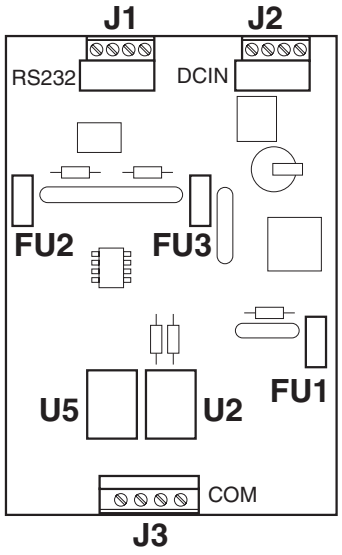
2.2.3 Checking output voltages on the IND226x

Voltage	Measuring point	Setpoint [V DC]
Analog weighing platform	B1–B7	4.9 ... 5.1 V
Active input	I1–I2	3.2 ... 3.4V

2.3 Checking the interface converter ACM200

DANGER OF ELECTRIC SHOCK

➜ De-energize the ACM200 before opening it.



Plug	Connection
J1	RS232
J2	Power supply
J3	Intrinsically safe connection to weighing terminal

2.3.1 Checking the ACM200 mainboard

1. Carry out a visual inspection whether the fuses FU1, FU2, FU3 are defective.
2. Test the fuses using an ohmmeter. When doing so, make sure that the coating of the fuses is not damaged.
   If R < 20 Ω, the fuse is in order.
3. Carry out a visual inspection of the ICs U2 and U5 whether the soldering points are in order.

2.3.2 Checking the function of the ACM200

DANGER OF ELECTRIC SHOCKA

➜ Before carrying out the function test, close the ACM200 housing.

1. Remove the RS232 plug-in connection from J1.
2. Connect RxD and TxD in order to jumper J1.
3. Connect J3 to the weighing terminal using an intrinsically safe connection cable.
4. Close the cover of the ACM200.
5. Apply voltage to the ACM200.
6. Carry out the function test in Technician mode: see IND226x operating instructions, menu item F5.5.

If the same digits are shown in the display from the left and right, the mainboard is in order.

2.4 Faults and their rectification

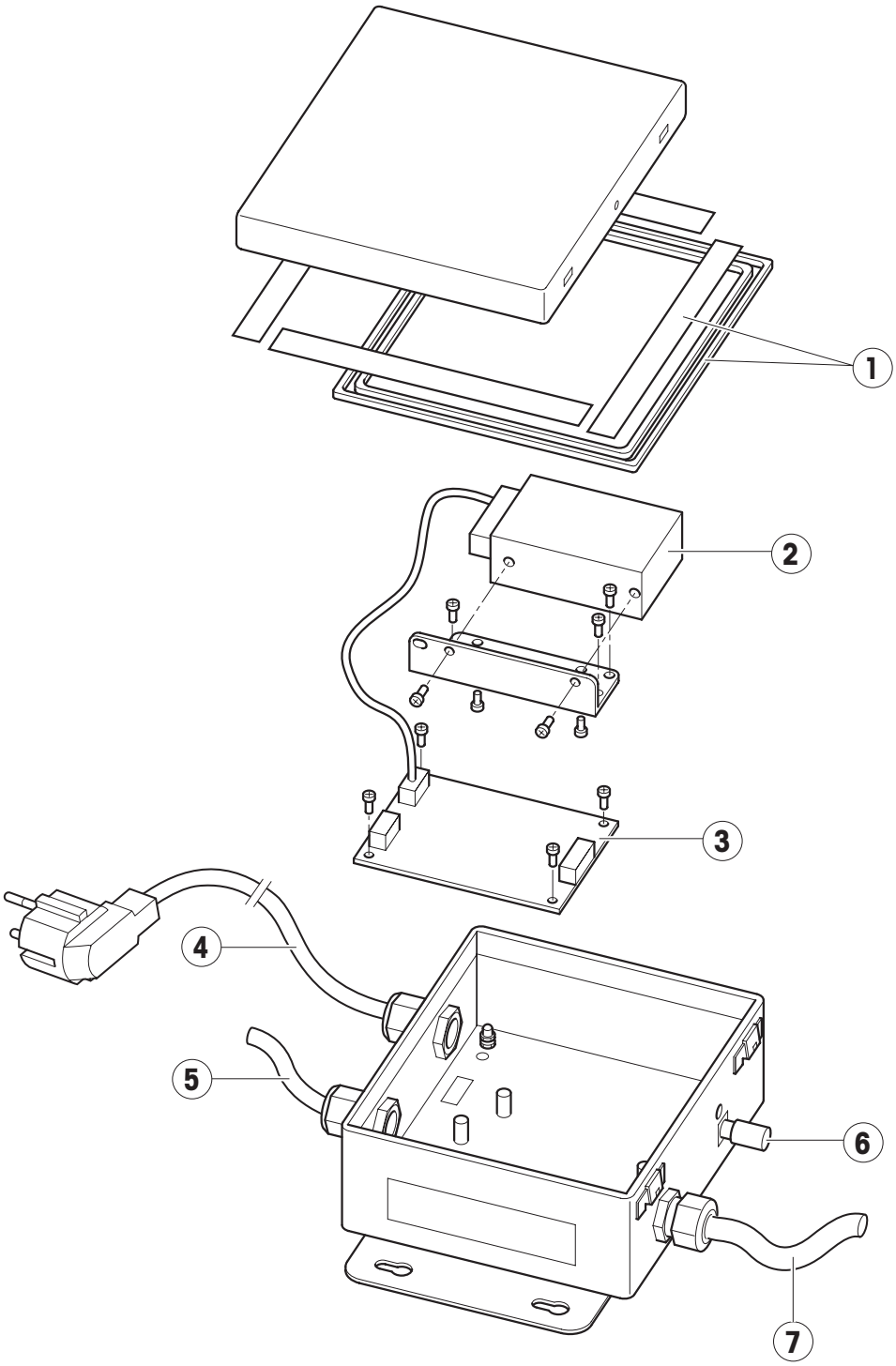
Fault	Possible causes	Rectification
No display at terminal	• Terminal is switched off	➜ Switch on terminal
	• Mains voltage not connected	➜ Notify owner's electrician
	• Keyboard faulty	➜ Replace cover incl. keyboard, see Section 4.3.2
	• IND226x mainboard defective	➜ Replace the IND226x mainboard, see Section 4.3.1
---- is displayed or The weight display changes constantly	• Unrest on the weighing platform	➜ Eliminate unrest on the weighing platform
	• Weighing platform faulty	➜ Replace the weighing platform
	• Analog voltage too low	➜ Checking the voltages of the A/D converter
		➜ Check the cabling
		➜ Adhere to the max. cable lengths
	• Weighing platform impedance< 87 Ω	➜ Ensure that the weighing platform impedance is ≥ 87 Ω.
Measured value negative despite load	• Analog scale connected incorrectly to the IND226x mainboard	➜ Check connection of weighing cell cable and correct if necessary
Measured value changes too low	• A/D converter of the IND226x not yet adjusted	➜ Adjust the A/D converter

Fault	Possible causes	Rectification
Terminal does not start	• Power supply unit faulty	➜ Check the voltage at the APS500/ APS501 or PSUx and replace defective components if necessary
	• External Battery Pack not charged	➜ Charge the external Battery Pack
	• External Battery Pack defective	➜ Replace the external Battery Pack
No data transfer to measuring cell	• Mainboard defective	➜ Check the output voltage of the analog weighing platform
		➜ Check the 5-V analog voltage of the A/D converter
		➜ If appropriate, replace the mainboard
	• Ex-i cable defective	➜ Replace weighing platform cable
	• Measuring cell faulty	➜ Replace measuring cell (see the service manual of the connected weighing platform)
No data transfer via serial interface	• Mainboard ACM defective	➜ Replace mainboard ACM, see section
	• Unrest on the weighing platform	➜ Eliminate unrest on the weighing platform
	• Parameter setting faulty	➜ Check parameters of peripheral device and weighing terminal
	• Transfer protocol setting faulty	➜ Set transfer protocol properly
	• Intrinsically safe connection cable defective	➜ Replace intrinsically safe connection cable
	• Interface connection cable defective	➜ Replace interface connection cable
	• Interface defective	➜ Replace interface
	• Interface not connected to the mainboard IND226x	➜ Connect interface to mainboard
	• Wrong interface installed	➜ Install Interface IND
No entry via membrane keyboard possible	• Keyboard cable not inserted or inserted incorrectly at the IND226x mainboard	➜ Insert keyboard cable properly
	• Keyboard faulty	➜ Replace cover
	• IND226x mainboard defective	➜ Replace the IND226x mainboard, see Section 4.3.1
Err 3	• EEPROM error	➜ Switch the weighing terminal off then on
Err 6	• EEPROM read/write error	➜ Replace the IND226x mainboard, see Section 4.3.1

Fault	Possible causes	Rectification
Err 32	• Impermissible values entered in Block F1	➜ Repeat the entry with correct values
Err 35	• Weighing platform in motion during adjusting	➜ Ensure that the weighing platform is resting
Err 70	• Keyboard error	➜ Replace the housing cover, see Section 4.3.2
EEE	• In case of certified weighing platforms: Zero setting range exceeded during switching on	➜ Unload weighing platform
–EEE	• In case of certified weighing platforms: Zero setting range below limit during switching on	➜ Place the load plate on (correctly)
no DTA	• Second display does not receive any valid data	➜ Check the communication settings ➜ Check data cable connections
L - - - - J	• Underload	➜ Press →0← ➜ Place the load plate on.
r - - - -]	• Overload	➜ Reduce the load
r - n0 -] L - n0 - J	• Zero setting outside zero-set range	➜ Unload weighing platform
- - n0 - -	• Key function cannot be executed	➜ Return to the gross mode
- - - - - -	• Key function cannot be executed, scale in motion	➜ Ensure that the weighing platform is resting
Weighing terminal switches off automatically	• Automatic switching-off activated • Battery level too low	➜ Unload the weighing platform and, if appropriate, configure Display Timeout and Power Off differently ➜ Charge the Battery Pack
Weighing terminal remains dark after being switched on	• No or incorrect voltage supply	➜ Check the connection of the supply unit ➜ Test the voltages on the mainboard

3 Spare parts

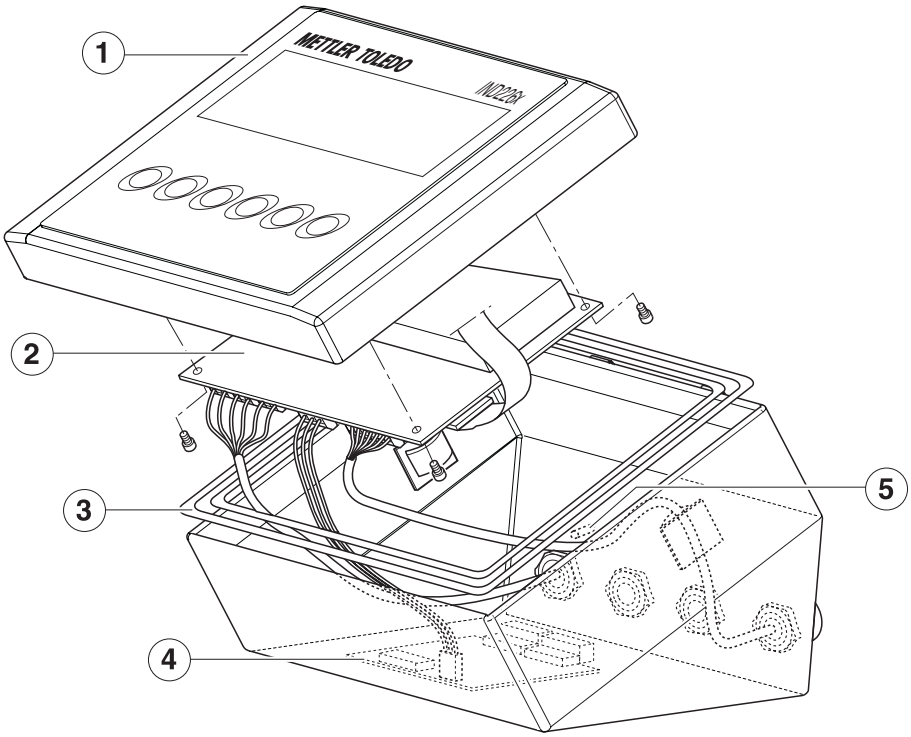
3.1 Exploded drawing ACM200



3.2 Spare parts list ACM200

Item	Designation	Part number
1	Housing seal	72 215 006
2	Wide range power supply unit	22 016 769
3	Mainboard ACM200	22 016 768
4	Power cable with plug EURO GB USA CH DK	 72 215 007 72 215 008 72 215 009 72 215 010 72 215 011
5	RS232 interface cable	72 215 012
6	Mantle terminal, set 2.5 mm^2 and 4.0 mm^2	00 504 664
7	Ex-i connection cable	72 215 013

3.3 Exploded drawing IND226x



3.4 Spare parts list IND226x

Item	Designation	Part number
1	Housing cover, complete with keyboard	22 018 016
2	IND226x mainboard	22 018 017
3	Housing seal	22 018 018
4	Serial interface module Interface IND Interface Remote	 22 018 019 22 018 020
5	Mantle terminal, set 4.0 mm^2	00 504 664

4 Repairs

4.1 Safety notes

ATTENTION

➜ De-energize the system before opening the device.

➜ Ensure that you are grounded before touching electronic components.

➜ Always place electronic components on antistatic materials.

CAUTION

The clip fasteners of the housing cover have sharp edges. Danger of injury.

➜ Do not touch the housing cover at the (six) clip fasteners in order to avoid cuts to fingers.

4.2 Opening the devicews

➜ Remove the weighing terminal from the stand or retainer and transport it together with the weighing platform and power supply unit into the non-hazardous area. If this is not possible, repair the terminal particularly carefully.

1. Slide a screwdriver into the holes at the front of the housing cover until a clear snapping noise is heard and the front clip fasteners can be removed.
2. Lid the cover up and the front and press against it. The rear clips are released with a clear sound.
3. Lift off the cover and place it carefully in front of the terminal.

4.3 IND226x repair

4.3.1 Replacing mainboard

Caution

The IND226x weighing terminal is reset to the default value when the mainboard is replaced.

➜ Note the customer-specific configuration and reset it in the menu after the mainboard has been replaced.

1. Open weighing terminal, see Section 4.2.
2. Disconnect the weighing cell cable, power cable and, if appropriate, cables of the active input and of the serial interface from the respective terminal blocks (P1-9, B1-7, I1-2, J4)
3. Disconnect the keyboard cable and any other serial interface cable from the mainboard.

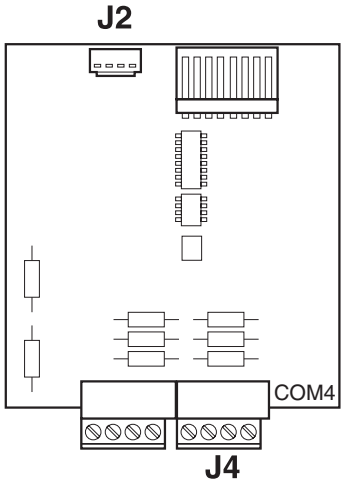
4. Loosen the mounting screws and remove the mainboard.
5. Insert and screw down the new mainboard.
   Caution: Only stainless-steel screws may be used to fasten the mainboard.
6. Reconnect the keyboard cable and any other serial interface cable back to the mainboard.
7. Connect all the cables (weighing cell, power supply unit and, if appropriate active input and serial interface) in accordance with the terminal diagram ME-72203677, found in the Guide for Installers manual, page 16.
8. Fasten the cables in the corresponding cable holders mounted on the side of the housing.

4.3.2 Replacing the cover

1. Open weighing terminal, see Section 4.2.
2. Remove the keyboard cable from the mainboard and loosen the terminals of the mains connection and of the weighing platform connection.
3. Loosen the weighing cell cable, power cable and, if appropriate, cables of the active input and of the serial interface from the respective terminal blocks (P1-9, B1-7, I1-2, J4)
4. Loosen the two cover retainer straps and remove the cover.
5. Remove the mainboard from the old cover and insert it into the new cover.
   Caution: Only stainless-steel screws may be used to fasten the mainboard.
6. Fasten the two cover retainer straps on the new cover.
7. Connect the keyboard cable to the mainboard.
8. Connect all the cables (weighing cell, power supply unit and, if appropriate active input and serial interface) in accordance with the terminal diagram ME-72203677, refer to the installation instructions.
9. Fasten the cables in the corresponding cable holders on the side of the housing.

4.3.3 Replacing the serial data interface

1. Pull of the plugs J2 and J4 (COM4) at the serial interface.
2. Loosen the fastening screws.
3. Insert the new serial data interface in the housing and fasten with 3 screws.
4. Plug the plugs J2 and J4 in again.



4.3.4 Closing the weighing terminal

ATTENTION
The following must be ensured during installation:

➜ Before closing the weighing terminal, ensure that all cables are secured in the cable holders at the lower housing section, refer to the exploded drawing.

➜ Ensure the correct positioning of the seals (cover seal and earthing cable glands). Replace damaged seals.

➜ Connect all the connection cables in accordance with the terminal diagram ME-72203677 and check them, refer to the Guide for Installers manual, page 16.

➜ Close the weighing terminal so that the cover latches audibly at all four clip fasteners.
Caution: If the weighing terminal is not closed correctly, degree of protection IP66 is not ensured and therefore its use in Zone 21 no longer possible.

4.4 ACM200 repair

4.4.1 Replacing the ACM200 mainboard

1. Open the ACM200, see Section 4.2.
2. Remove the cable connections J1, J2 and J3 from the mainboard.
3. Loosen the mounting screws and remove the mainboard.
4. Insert and screw down the new mainboard using stainless steel screws.
5. Reconnect the cable connections J1, J2 and J3.

4.4.2 Replacing the power supply unit

1. Open the ACM200, see Section 4.2.
2. Dismantle the wide range power supply unit with clamp by removing the 3 screws from the housing base.
3. Separate the power supply unit by unscrewing 2 screws from the clamp.
4. Loosen the power supply unit screws and pull the power cable so that the screws at the connection terminals of the power supply unit can be opened using the screwdriver.
5. Remove the power cable and connection cable to the mainboard from the defective power supply unit and connect to the new power supply unit in accordance with terminal diagram ME-72203677.
6. Mount the clamp with 2 screws to the power supply unit.
7. Pull the power cable and tighten the power cable screws again.
8. Fasten the clamp including power supply unit with 3 screws to the housing base.

4.4.3 Closing the ACM200

➜ Be sure to observe the following points when closing the ACM200:

- Ensure the correct positioning of the seals in the cover and at the earthing cable glands. Replace damaged seals.
- Connect all the connection cables in accordance with the terminal diagram ME-72203677 and check them, see IND226x installation instructions.
- Close the ACM200 so that the cover latches in audibly at the four clip fasteners at the corners.

5 Checklists

5.1 Maintenance checklist

Visual inspection

➜ Check condition of the following scale components:
- Housing
- Keyboard and display membrane
- Weighing platform
- Peripherals

➜ Check condition of the following cables:
- Supply cable APS500 / APS501 or PSUx
- Weighing platform connection cable
- Data transmission cable between IND226x and ACM200 (if it exists)
- Cable of the active input (if it exists)
- Power cable ACM200, APS500 / APS501 or PSUx
- RS232 cable ACM200

➜ Check for protected position of cables.

➜ For verified scales: Check sealing and slide marks.

Function check

➜ Check functions by making entries via the keyboard (see Operating Instructions manual).

➜ Check settings of the weighing platform (see service manual of the connected weighing platform):
- Calibration
- Corner load
- Linearity
- Hysteresis

➜ Check the correctness of the cable assignment in accordance with the terminal diagram ME-72203677, refer to the Guide for Installers manual, page 16:
- Power supply connection APS500 / APS501, PSUx or Battery Pack
- Weighing platform connection
- Data transmission cable between IND226x and ACM200 (if it exists)
- Active input (if it exists)
- Power cable ACM200
- RS232 cable ACM200
- Connection cable mainboard ACM200 – power supply unit ACM200

5.2 Service checklist

Carry out the following check procedure at the terminal and the weighing platform before troubleshooting and after servicing:

At the terminal

➜ Check for an operating error.

➜ Check weighing platform connection cable and supply cable.

➜ Check functions by making entries via the keyboard (see Operating Instructions manual).

➜ Run the display and keyboard test (refer to the Operating Instructions manual).

➜ Check all the terminal connections for firm seating.

➜ Check connected devices.

At the weighing platform

➜ Check support of the weighing platform.

➜ Ensure that the load plate is free and does not touch anything.

➜ Check maximum load and linearity.

➜ Check the play of all the stops and limits.

At the ACM200

➜ Check the IND226x connection cable and the supply cable.

➜ Check the data transmission (Technician mode F5.5).

➜ Check whether all the cable connections are wired and fastened correctly.

6 Menu

The menu consists of the user menu with the application settings and the technician menu with the scale settings.
A detailed menu description is available in the IND226x Operating Instructions manual.

6.1 Entry into the technician menu

1. Press and hold ⇨ in the gross mode until **MASTER** appears in the display.
2. Enter the password →0← →T← →0← →T← and confirm with ⇨.
   SETUP is displayed in the display.
3. Press ⇨.
   F1 is displayed in the display. All the parameters can be adapted.

Information for certified weighing systems (OIML or NTEP)
The parameters F1, F5.1 und F5.4 are disabled at certified weighing systems.
Proceed as follows in order to change these parameters:

1. Switch off the weighing terminal and open it.
2. Close the certification switch (W&M) on the mainboard and switch on the weighing terminal.
   SETUP is displayed. All the parameters can be modified.
3. After the configuration has been carried out, save the new configuration by using F6. CALOFF appears in the display.
4. Switch off weighing terminal and open.
5. Open the certification switch (W&M).
6. Close the weighing terminal so that the cover latches in audibly at all four clip fasteners.
7. Seal the weighing terminal.

6.2 Overview

U = can be changed both in the User menu and in the Technician menu
T = can only be changed in the Technician menu

	F1	**Scale menu**		**F3**	**Terminal menu**
	F1.1	Verifiability	**U**	F3.1.1	Sleep mode
	F1.2.1	Weight units		F3.2	Automatic power interruption
	F1.2.3	Capacity of the first weighing range		F3.10	Reset terminal settings
	F1.2.4	Resolution of the first weighing range		**F4**	**Data transfer menu**
	F1.3.1	Geo value		F4.1	Connections
	F1.3.2	Linearization during adjusting		F4.2.1	Line format
	F1.3.3	Calibration		F4.2.2	Output format
	F1.3.4	CalFREE		F4.2.3	Language
	F1.4.1	Automatic setting to zero		F4.2.4	Line feed
T	F1.4.2	Zero setting when switching on	**U**	F4.2.5	Threshold for automatic printing
	F1.4.3	Manual setting to zero		F4.2.6	Minimum unloading for autom. printing
	F1.5.1	Automatic taring		F4.3.1	Baud rate
	F1.5.2	Automatic clearing of the tare weight		F4.3.2	Data bits/parity
	F1.5.3	Tare blocking		F4.3.3	Xon/Xoff
	F1.5.4	Threshold for automatic taring		F4.3.4	Checksum
	F1.5.5	Threshold for autom. tare clearing		F4.10	Reset data transfer
	F1.6.1	Digital filter		**F5**	**Maintenance**
	F1.6.2	Motion		F5.1	Calibration values
	F1.10	Reset Parameter 1.x(.x)		F5.1.1	Display internal zero-point value
	F2	**Function key menu**		F5.1.2	Display weight value for half maximum load
	F2.1	Function of the F-key		F5.1.3	Display internal half-load value
	F2.2	Over/Under weighing		F5.1.4	Display weight value for maximum load
	F2.2.1	Operating mode		F5.1.5	Display internal maximum load value
	F2.2.2	Specification of the target weight	**T**	F5.2	Keyboard test
	F2.2.3	Upper tolerances		F5.3	Display test
	F2.2.4	Lower tolerances		F5.4	Internal resolution of the display
U	F2.4	Remote display		F5.5	COM1 test
	F2.5	Active input		F5.6	I/O test
	F2.61	MinWeighEN		F5.7	Print settings
	F2.6.2	Input mode		F5.8	Enter serial number
	F2.6.3	MinWeigh		F10	Reset all the parameters F1 ... F4
	F2.6.4	Input mode	**U**	**F6**	**Exit menu**
	F2.6.5	T as %			
	F2.6.6	Factor			
	F2.10	Reset function key settings			

6.3 Software download

The IND Terminal Manager of METTLER TOLEDO or a HyperTerminal connection can be used to load the software updates from a PC via the ACM200 and the serial interface to the IND226x.

Note
Always make a backup of the previous software and customer-specific settings before downloading the software.

1. Set up the IND Terminal Manager or establish a new HyperTerminal connection (1k Xmodem or Xmodem) at the PC with the following parameters:
   - 19200 baud
   - 8 data bits
   - 1 stop bit
   - no handshake
   - no parity
2. Download and select the file for the software update to the PC.
3. Connect the weighing terminal via the RS232 data interface of the ACM200 to the PC.
4. Switch off and open the weighing terminal, see Section 4.2.
5. Set the certification switch on the mainboard, i.e. close the jumper.
6. Press the Send button of HyperTerminal or the Start button of the IND Terminal Manager and then switch on the weighing terminal.
   "FLASH" is displayed and start the software download.
7. After the software has been downloaded, "DONE" is displayed.
8. Open the certification switch on the mainboard.

Notes

- A software download may not be interrupted.
- If a software download could not be completed due to an interruption in the power supply, carry out the software download again.
- If the software update fails again, the mainboard has to be replaced.

7 Geo value table

Northern or southern latitude in degrees and minutes	Height above sea level in meters										
	0 325	325 650	650 975	975 1300	1300 1625	1625 1950	1950 2275	2275 2600	2600 2925	2925 3250	3250 3575
	Height above sea level in feet										
	0 1060	1060 2130	2130 3200	3200 4260	4260 5330	5330 6400	6400 7460	7460 8530	8530 9600	9600 10660	10660 11730
0° 0′ – 5° 46′	5	4	4	3	3	2	2	1	1	0	0
5° 46′ – 9° 52′	5	5	4	4	3	3	2	2	1	1	0
9° 52′ – 12° 44′	6	5	5	4	4	3	3	2	2	1	1
12° 44′ – 15° 6′	6	6	5	5	4	4	3	3	2	2	1
15° 6′ – 17° 10′	7	6	6	5	5	4	4	3	3	2	2
17° 10′ – 19° 2′	7	7	6	6	5	5	4	4	3	3	2
19° 2′ – 20° 45′	8	7	7	6	6	5	5	4	4	3	3
20° 45′ – 22° 22′	8	8	7	7	6	6	5	5	4	4	3
22° 22′ – 23° 54′	9	8	8	7	7	6	6	5	5	4	4
23° 54′ – 25° 21′	9	9	8	8	7	7	6	6	5	5	4
25° 21′ – 26° 45′	10	9	9	8	8	7	7	6	6	5	5
26° 45′ – 28° 6′	10	10	9	9	8	8	7	7	6	6	5
28° 6′ – 29° 25′	11	10	10	9	9	8	8	7	7	6	6
29° 25′ – 30° 41′	11	11	10	10	9	9	8	8	7	7	6
30° 41′ – 31° 56′	12	11	11	10	10	9	9	8	8	7	7
31° 56′ – 33° 9′	12	12	11	11	10	10	9	9	8	8	7
33° 9′ – 34° 21′	13	12	12	11	11	10	10	9	9	8	8
34° 21′ – 35° 31′	13	13	12	12	11	11	10	10	9	9	8
35° 31′ – 36° 41′	14	13	13	12	12	11	11	10	10	9	9
36° 41′ – 37° 50′	14	14	13	13	12	12	11	11	10	10	9
37° 50′ – 38° 58′	15	14	14	13	13	12	12	11	11	10	10
38° 58′ – 40° 5′	15	15	14	14	13	13	12	12	11	11	10
40° 5′ – 41° 12′	16	15	15	14	14	13	13	12	12	11	11
41° 12′ – 42° 19′	16	16	15	15	14	14	13	13	12	12	11
42° 19′ – 43° 26′	17	16	16	15	15	14	14	13	13	12	12
43° 26′ – 44° 32′	17	17	16	16	15	15	14	14	13	13	12
44° 32′ – 45° 38′	18	17	17	16	16	15	15	14	14	13	13
45° 38′ – 46° 45′	18	18	17	17	16	16	15	15	14	14	13
46° 45′ – 47° 51′	19	18	18	17	17	16	16	15	15	14	14
47° 51′ – 48° 58′	19	19	18	18	17	17	16	16	15	15	14
48° 58′ – 50° 6′	20	19	19	18	18	17	17	16	16	15	15
50° 6′ – 51° 13′	20	20	19	19	18	18	17	17	16	16	15
51° 13′ – 52° 22′	21	20	20	19	19	18	18	17	17	16	16
52° 22′ – 53° 31′	21	21	20	20	19	19	18	18	17	17	16
53° 31′ – 54° 41′	22	21	21	20	20	19	19	18	18	17	17
54° 41′ – 55° 52′	22	22	21	21	20	20	19	19	18	18	17
55° 52′ – 57° 4′	23	22	22	21	21	20	20	19	19	18	18
57° 4′ – 58° 17′	23	23	22	22	21	21	20	20	19	19	18
58° 17′ – 59° 32′	24	23	23	22	22	21	21	20	20	19	19
59° 32′ – 60° 49′	24	24	23	23	22	22	21	21	20	20	19
60° 49′ – 62° 9′	25	24	24	23	23	22	22	21	21	20	20
62° 9′ – 63° 30′	25	25	24	24	23	23	22	22	21	21	20
63° 30′ – 64° 55′	26	25	25	24	24	23	23	22	22	21	21
64° 55′ – 66° 24′	26	26	25	25	24	24	23	23	22	22	21
66° 24′ – 67° 57′	27	26	26	25	25	24	24	23	23	22	22
67° 57′ – 69° 35′	27	27	26	26	25	25	24	24	23	23	22
69° 35′ – 71° 21′	28	27	27	26	26	25	25	24	24	23	23
71° 21′ – 73° 16′	28	28	27	27	26	26	25	25	24	24	23
73° 16′ – 75° 24′	29	28	28	27	27	26	26	25	25	24	24
75° 24′ – 77° 52′	29	29	28	28	27	27	26	26	25	25	24
77° 52′ – 80° 56′	30	29	29	28	28	27	27	26	26	25	25
80° 56′ – 85° 45′	30	30	29	29	28	28	27	27	26	26	25
85° 45′ – 90° 00′	31	30	30	29	29	28	28	27	27	26	26

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