

Datex-Ohmeda
S/5™ NIBP Module, M-NIBP (Rev. 05)
Technical Reference Manual Slot



All specifications are subject to change without notice.

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NIBP Module, M-NIBP

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INTRODUCTION

This section provides information for the maintenance and service of the Non-Invasive Blood Pressure parameter module, M-NIBP. The Non-Invasive Blood Pressure Module, M-NIBP, is a double width plug-in module designed for use with the S/5 monitors.



Figure 1 **Non-invasive blood pressure Module, M-NIBP**

NOTE: Do not use identical modules in the same monitor simultaneously. The M-NIBP and M-NE(12)STPR/-NESTR/-NETPR/M-MRI/M-MRIP are considered as identical modules.

1 SPECIFICATIONS

1.1 General specifications

Module size, W × D × H	75 × 180 × 112 mm/3.0 × 7.1 × 4.4 in
Module weight	0.7 kg/1.5 lbs
Power consumption	about 4 W

1.2 Typical performance

Oscillometric measurement principle.

Measurement range	adult	25...260 mmHg
	child	25...195 mmHg
	infant	15...145 mmHg
Accepted HR	30...250 bpm	
Measurement interval	from continuous to 1h, 2h, 4h	
Measurement time, typical	adult	23 s
	infant	20 s
Initial inflation pressure	adult	185 ±10 mmHg
	child	150 ±10 mmHg
	infant	120 ±10 mmHg
Venous stasis	adult	80 ±10 mmHg / 2 min
	child	60 ±10 mmHg / 2 min
	infant	40 ±10 mmHg / 1 min
Cuff widths	Please see <i>User's Guide</i>	

1.3 Technical specifications

Deflation rate, HR dep.	5...13 mmHg/sec
Inflation rate, typical	20...185 mmHg, 1...5 s

Automatic software control, max. inflation pressure

adult	280 ±10 mmHg
child	200 ±10 mmHg
infant	150 ±10 mmHg

Over pressure limit, stops measurement after 2 seconds

adult	320 mmHg
child	220 mmHg
infant	165 mmHg

Safety valve limits the maximum cuff pressure to 320 mmHg in adult/child mode or 165 mmHg in infant mode. Independent timing circuit limits pressurizing (>5 mmHg) time to 2 minutes 10 seconds maximum in adult/child mode, and 1 minute 5 seconds in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, inflation pressure is increased typically 50 mmHg.

Max. measurement time	adult	2 min.
	child	2 min.
	infant	1 min.

Pressure transducer accuracy is better than ± 3 mmHg or ± 2 % (whichever is greater). Max. error ± 4 mmHg.

Protection against electrical shock	Type BF defibrillation proof
-------------------------------------	------------------------------

2 FUNCTIONAL DESCRIPTION

2.1 Measurement principle

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for NIBP measurement:

- NIBP module
- Twin hose (adult or infant model)
- Blood pressure cuffs (different sizes)

2.2 Main components

The NIBP module consists the following parts:

- NIBP board
- Pneumatics and hosing
- NIBP air pump
- Zero valve
- Check valve
- Bleed valve
- Exhaust valves (2)
- Pressure transducers (2)
- Module keyboard and status indicator LEDs
- Front panel keys: Auto On/Off, Set Cycle Time, Stat On/Off, Start/Cancel

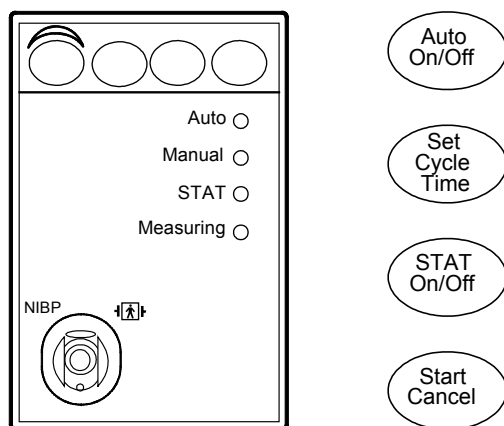


Figure 2 Front panel of NIBP Module

2.2.1 NIBP board

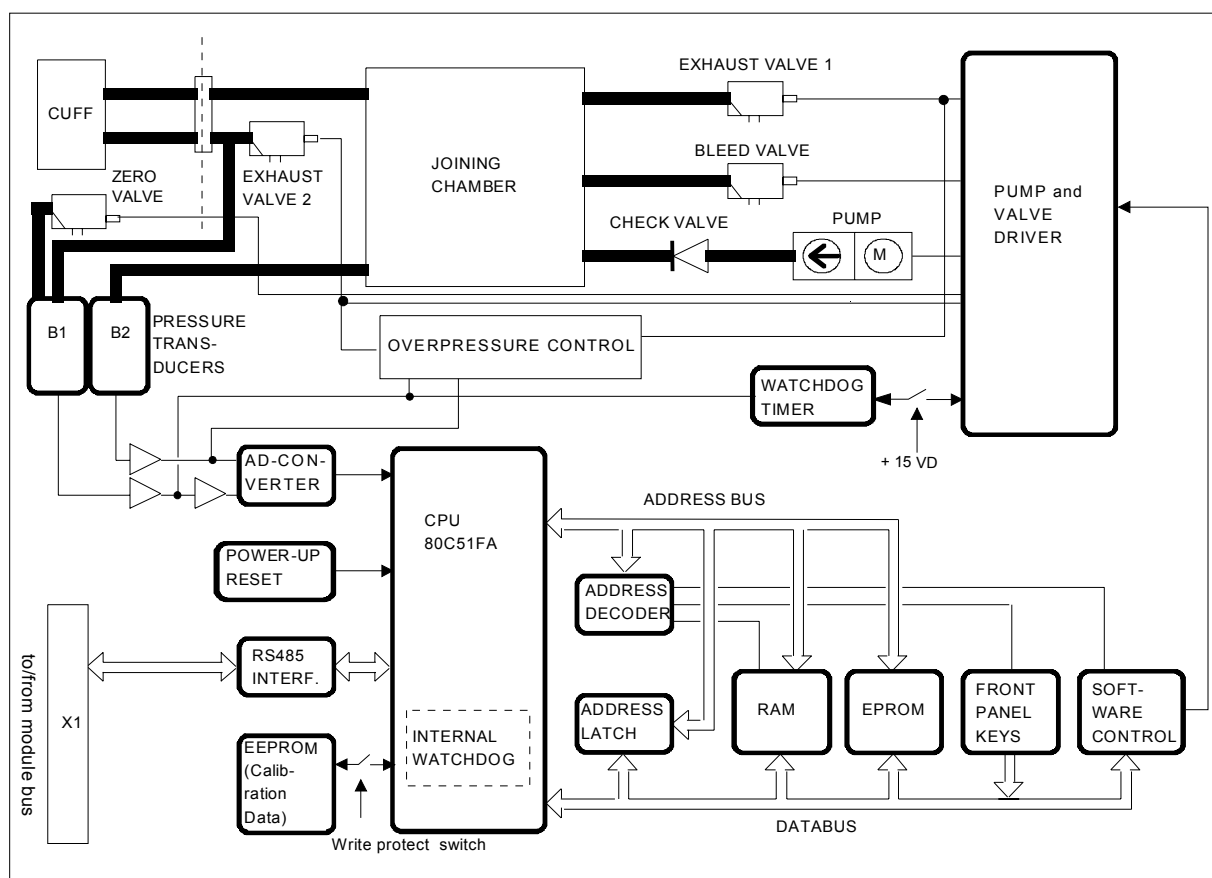


Figure 3 NIBP board functional block diagram

Pressure transducers

The NIBP board contains two pressure transducers. They are of piezoresistive type. One is used for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement (B1). The other is used for detection of cuff hose type, cuff loose and cuff occlusion situations etc. (B2). The transducers are internally temperature compensated. They are supplied by a constant voltage and their output voltage changes up to 40 mV max. (50 kPa, 375 mmHg).

Signal processing

Two signals from the pressure transducers are amplified and sent to A/D converter. After the converter, digitized signals are sent to microprocessor for data processing. Before the converter, one of the signals is used to adjust the offset to the pressure safety level.

The NIBP board is controlled with 80C51FA microprocessor at 16 MHz oscillator frequency. Communication between the module and the monitor CPU board is established through RS485 serial interface at 500 kbps data transfer rate.

Memory

NIBP program memory (EPROM) size is $128k \times 8$. RAM size is $32k \times 8$ bit and it stores variable values in NIBP measurement. EEPROM is size 64×16 bit and is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and module serial number.

Software control

Software controls valves and pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used at pump/valve failures.

In addition to external RS485 reset line the microprocessor system is equipped with its own power-up reset.

Watchdog timer

The NIBP board is equipped with software independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than preset time. As soon as the cuff pressure rises over a specified pressure limit, timer starts counting. The timer is adjusted to stop the pump and open the valves in 2 minutes 10 seconds in adult/child mode and in 1 minute 5 seconds in infant mode.

Valves

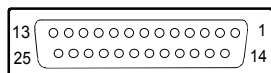
Exhaust valves are used for emptying the cuff and the joining chamber after the measurement. Exhaust valve 1 is also used as safety valve in infant mode. Valve opens at 165 mmHg. Exhaust valve 2 is also used as safety valve in adult mode and opens at 320 mmHg. Bleed valve is used for emptying the cuff during measurement. Zero valve is used for connecting the pressure transducer B1 to open air.

Power supply section

All connections are established via 25-pin connector (D-type, female). The module needs +5 V, ± 15 V, and +15 VD (dirty) power supply to operate. The pump and the valves use separate +15 VD power line. The supply voltages are generated in the power supply section of the S/5 monitor. The reference voltages $\pm 5 V_{ref}$ and $+10 V_{ref}$ are generated on the NIBP board.

2.3 Connectors and signals

2.3.1 Module bus connector



Module Bus connector (X1)

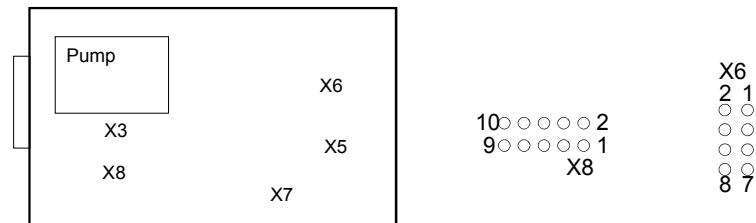
Pin No	I/O	Signal	Not used
1	I	RESET_RS485	
2	I	-15 VDC	
3	I	+15 VDIRTY	
4	I	+15 VDC	
5	I/O	-DATA_RS485	
6	I/O	DATA_RS485	
7	-	Ground & Shield	
8	I	-RESET_RS485	
9	I	CTSB	*
10	O	RTSB	*
11	I	RXDB	*
12	O	TXDB	*
13	-	Ground & Shield	
14	I	+32 VDIRTY	*
15	I	GroundDIRTY	
16	I	CTSC	*
17	O	RTSC	*
18	I	RXDC	*
19	O	TXDC	*
20	-	ON/STANDBY	*
21	-	PWM_ECG	*
22	-	RXDD_RS232	*
23	-	TXDD_RS232	*
24	I	+5 VDC	
25	I	+5 VDC	

***Not used in the M-NIBP module**

2.3.2 Test points

NIBP board

There are test pad blocks on solder side.
X8 and X6 pads and voltages are:



X8

Pin No	Signal
1	GND
2	WD out
3	reset
4	+5 V
5	+15 V dirty
6	+15 V
7	-15 V
8	-
9	-
10	GND

X6

Pin No	Signal
1	GND
2	A1 output
3	- 5 V
4	+5 V ref
5	B1 out - (A1 input)
6	B1 out +
7	B2 out +
8	B2 out -

3 SERVICE PROCEDURES

3.1 General service information

Field service of the M-NIBP module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.


CAUTION Only trained personnel with the appropriate tools and equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service check is recommended to be performed after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (*Appendix A*) which should be filled in when performing the procedures.

The mark  in the instructions means that the check form should be signed after performing the procedure.

The procedures are designed for monitors with S/5 monitor software of revision 01. However, most of the procedures also apply to monitors, which contain some other monitor software type/revision.

3.2.1 Recommended tools

Tool	Order No.	Notes
Pressure manometer		
Adult cuff & hose		
Infant cuff & hose		
Screwdriver		

3.2.2 Recommended parts

Part	Order No.	Notes
NIBP pump filter	57142	

- Detach the module box by removing the two screws from the back of the module. Be careful with loose latch and spring pin for locking.
1. Check internal parts:
 - screws are tightened properly
 - cables are connected properly
 - all IC's that are on sockets are attached properly
 - EMC covers are attached properly
 - the calibration protection switch on the NIBP board is intact
 - tubes are not pinched and there are no sharp bends on them

- tubes are connected properly
- the upper of the cuff connector tubes, as well as the related tube connector are marked
- there are no loose objects inside the module



2. Check external parts:

- the front cover and the front panel sticker are intact
- the cuff connector is intact and is attached properly
- the module box, the latch and the spring pin are intact



3. Replace the NIBP pump filter, if necessary.



- Reattach the module box and check that the latch is moving properly.
- Switch the monitor on and wait until the monitoring screen appears.
- Make sure that NIBP information is selected to be shown on the screen:

Monitor Setup - Screen 1 Setup - Digit Fields - Field 2 - NIBP

4. Plug in the module. Check that it goes in smoothly and locks up properly



5. Check that the module is recognized, i.e. the NIBP headers appear on the selected digit field.



6. Enter the service menu:

Monitor Setup - Install/Service (password 16-4-34) - **Service** (password 26-23-8)

Take down the information regarding NIBP module software by selecting **Scroll Vers** and turning the ComWheel.



7. Enter the NIBP module service menu:

Parameters - NIBP

Check that the 'Timeouts', 'Bad checksums' and 'Bad c-s by mod' values are not increasing faster than by 50 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the 'RAM', 'ROM' and 'EEPROM' show all OK.



8. Check the front panel LEDs and membrane keys.

Select **Buttons/Leds**

Highlight the text **Auto ON**. Check that the LED for the autocycle measurement is turning on and off on the module front panel when pressing the ComWheel. Check also the other LEDs by selecting **Manual ON**, **STAT ON** and **Measur. ON**.

Press each of the module's membrane keys at least for one second. Check that the pressed key is identified, i.e. the text OFF changes to ON for the key in the menu.



9. Check the pump and valves.

Select **Pneumatics** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

Highlight **Start Pump** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

Highlight **Open Exh1**. Press the ComWheel and check that the pressure inside the tubing system starts to drop then press the ComWheel again. Check the other exhaust valve by the same way by selecting **Open Exh2** from the menu.

If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

Highlight **Open Zerovalve**. Press the ComWheel and check that the pressure B1 \cong 0 mmHg. Close the zero valve by pressing the ComWheel again and check that the pressure B1 is equal with the pressure B2.

Highlight **Set Valve**. Press the ComWheel and set the value under the text 'Pulse Valve' to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting **Previous Menu**.



10. Check the NIBP tubing system for leakages.

Select **Calibrations** from the NIBP service menu.

Keep the pressure manometer connected to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 265 mmHg and then the pump stops.

Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 5 mmHg per one minute. Release the pressure by pressing the ComWheel once more.



11. Calibration check.

Disconnect the pressure manometer. Select **Calibrations** and then highlight **Calibration Check**. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ± 10 mmHg.

Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

Recalibrate the NIBP measurement according to the instructions in the Technical Reference Manual, if necessary. Remember to set the calibration protection back on after the calibration.



12. Check the watchdog timer activation pressure.

Select **Pneumatics** from the NIBP service menu.

Keep the pressure manometer connected to the cuff connector. Pump up the pressure very slowly and note the value on the manometer when you hear a signal from the loudspeaker. The pressure at where the watchdog timer should activate with an audible signal is

Rev. 00-03 = 14 mmHg (9...19 mmHg)

Rev. 04 -> = 7.5 mmHg (5...10 mmHg)

Adjust the limit with the trimmer on the NIBP board, if necessary.



13. Check the watchdog timer.

Select **Watchdog** from the NIBP service menu.

Check the watchdog timer in the adult mode. Activate the timer by highlighting **Test ADULT** and then pressing the ComWheel. Check that the time beside the text 'Watchdog Interval' starts to run. Wait until you hear a signal from the loudspeaker and then check the time again. The time from the adult test should fall within 120...140 seconds.

Check the watchdog timer also in the infant mode by first selecting **Test INFANT** from the menu. The time from the infant test should fall within 60...70 seconds.



14. Check the safety valve.

Select **Safety Valve** from the NIBP service menu.

Keep the pressure manometer connected to the cuff connector.

NOTE: Make sure your pressure manometer can be used to measure pressures over 300 mmHg. If such a pressure manometer is not available, perform the check with an adult cuff that is connected around some round object, for example calibration gas bottle.

Highlight **Start Test**. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated. Check the pressure values 'Max press' and '2 s after stop' for both transducers. All the values should be within 290...330 mmHg.

Highlight **Adult**. Press the ComWheel and check that the text changes now to **Infant**. Select **Start Test** and wait until the pump stops and the pressure values on the screen have been updated. Check that the values 'Max press' and '2 s after stop' are all now within 154...165 mmHg.

Return to the normal monitoring mode by pressing **Normal Screen**.



15. Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses. Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message 'Cuff loose' appears on the screen within 30 seconds.

Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message 'Cuff occlusion' appears on the screen within 30 seconds.



16. Check that automatic inflation limits are in use:

NIBP - NIBP Setup - Inflation Limits - Auto - Previous Menu

Connect the cuff onto your arm, highlight **Start Ven.Stasis** in the NIBP menu and press the ComWheel. Check the module identifies the cuff, i.e. the text 'Adult' appears into the NIBP digit field for a short moment.

Keep the pressure inside the cuff for about half a minute in order to see that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.



17. Keep the cuff on your arm and perform one NIBP measurement. Check that the module gives a reasonable measuring result.



18. Connect an infant cuff to cuff connector and wrap it around your fingers. Start NIBP measurement and check that the module identifies the cuff, i.e. the text 'Infant' appears into the NIBP digit field. Cancel the measurement after the cuff identification.



19. Perform electrical safety check and leakage current test.



20. Check that the module functions normally after the performed electrical safety check.



21. Clean the module with suitable detergent.



- Fill in all necessary documents.

3.3 Disassembly and reassembly

Rev. 01-03 Disassemble the M-NIBP module in the following way. See the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with loose latch and spring pin for locking.
3. To detach the NIBP board remove the four corner screws from the back of NIBP board. The NIBP board and the front panel can be detached.
4. To free the front panel and the NIBP board, disconnect tubes and connectors.
5. Remove the five screws and lift off the plastic pump cover. NIBP pump, safety (over pressure) valve, and valve unit which includes two valves, wires and a connector will be exposed. Remove them.
6. Pull out pulse valve from the bottom of the NIBP frame.

Rev. 04 -> Disassemble the M-NIBP module in the following way. See the exploded view of the module.

1. Remove the two screws from the back of the module.
2. Pull the module box slowly rearward and detach it from main body. Be careful with loose latch and spring pin for locking.
3. To detach the NIBP board remove the support plate by 2 screws (item 25).
4. Remove the metal frame (item 26).
5. Detach the damping chamber with 3 screws.
6. Detach 2 screws (item 9).
7. To free the front panel and the NIBP board, disconnect tubes and connectors.
8. Remove the two screws and lift off the pump. NIBP pump, and valve unit which includes four valves, wires and a connector will be exposed. Remove them.

CAUTION Before reattaching the module box, make sure that the tubes are not pinched between the NIBP frame and the PC board.

NOTE: Take care that the connectors and especially the tubes are reconnected properly and to the right ports.

3.4 Adjustments and calibrations

3.4.1 Pressure safety level detection “OFFSET”

Remove two screws at the rear of the module. Remove the module box. Connect first the service cable (e.g. a long Gas interface cable) to the module connector inside the monitor frame and then to the rear connector of the module. Switch the monitor on. Go to the NIBP service menu and select **Pneumatics**. Pump reference pressure into the module:

Rev. 00-03 = 14 mmHg (9...19 mmHg)

Rev. 04 -> = 7.5 mmHg (5...10 mmHg)

Adjust the trimmer until AD5 signal sign changes from negative to positive. Re-check the adjustment, then lock the trimmer with for example nail polish.

3.4.2 NIBP calibrations

The electronics of NIBP pressure measurement is calibrated at the factory. Zeroing pressure is automatically maintained by the processor. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced. The calibration can be checked and recalibrated in the NIBP service menu.

The calibration of the primary pressure channel can also be checked from the NIBP setup menu (NIBP, NIBP Setup, Calibration Check). In this case the auto zeroing is performed at start - remove hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

Calibration check

1. Enter Calibration menu.

Calibration

Active Leak Test OFF

Calibration Check OFF

Protection OFF

Calibration

Previous Menu

2. Select 'Calibration Check' and press the ComWheel.
3. Connect an external precision manometer to the module.
4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display:

Pressure	Max. error	Example
0 mmHg	± 9 mmHg (=zero offset)	-2
100 mmHg	100 + zero offset ± 2 mmHg	98 ± 2
200 mmHg	200 + zero offset ± 3 mmHg	198 ± 2

If the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, it is recommended to recalibrate the module also when the error of B2 is larger than specified above to ensure best possible operation.

Calibration

1. Enter Calibration menu.
2. Remove hoses from front panel connector to enable proper zeroing.
3. Select **Calibration**. If it is not available, perform the steps A, B and C.

NOTE: Do not pull out the NIBP module from the monitor frame. The module must be in the frame during the whole procedure.

- A) Turn the toggle switch at the bottom of the NIBP module to enable the calibration. Turn the switch to the right by, for example, a sharp pencil. This enables menu selection 'Protection'. the message 'Calibration switch ON!' appears.
 - B) Select Protection OFF in the Calibration menu and press the ComWheel.
 - C) Return the toggle switch to the left. Menu selection **Calibration** is now enabled, and **Protection** is disabled. When the calibration is enabled, a message 'Calibration not protected' appears.
4. Start Calibration by pressing the ComWheel. Messages 'ZEROING' and 'ZEROED' will appear in the NIBP message field. After this a pressure bar will appear.
 5. Connect an external mercury manometer with pump to module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure about 200 mmHg according to the manometer. Calibration is possible in the range 150 to 300 mmHg.
 6. Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, press the ComWheel to confirm the calibration. The message 'Calibrating' will appear onto the NIBP digit field. After a few seconds it is followed by 'Calibrated', which means that the calibration has succeeded, and the new calibration data has been saved into EEPROM.

To set the protection on:

Turn the toggle switch to the right. Select **Protection** ON and press the ComWheel. Then turn the toggle switch back to the left.

7. Remove the module from the frame and plug it back again. Then perform Calibration Check (see the preceding page) to verify the new calibration.

4 TROUBLESHOOTING

4.1 Troubleshooting chart

Trouble	Cause	Treatment
No NIBP value displayed	NIBP not selected on screen.	Check monitor setup.
NIBP menu fading	No M-NIBP module, module not properly connected, or NIBP and NE(12)STPR/MRI module connected at the same time.	Plug in the module.
Artifacts-message	Unsuccessful measurement due to patient movements or shivering.	
Weak pulsation-message	Weak or unstable oscillation pulses due to: <ul style="list-style-type: none"> artifacts (accurate diastolic pressure difficult to measure) marked arrhythmia marked drop in diastolic pressure diastolic pressure difficult to measure improper cuff position or attachment too few pulses detected weak or unusual blood circulation may give systolic value 	Check patient condition and retry. Check any leaks and retry. Use proper size of cuff. Check attachment.
Call service Error X-message	NIBP hardware error. X = error number.	See the description of the error message code, the causes and the solutions listed in the next chapter.
'Cuff loose' message	1. Hose and/or cuff not connected. 2. Hose and cuff connected. Reason: <ul style="list-style-type: none"> cuff loosely wrapped leakage in cuff or hose leakage inside module pump does not work no pulses during the last three measurements 	1. Connect the hose and the cuff. 2. <ul style="list-style-type: none"> tighten the cuff replace cuff/hose check internal tubing and air chamber, and fix if necessary check pump connector; if OK, replace pump check cuff positioning

Trouble	Cause	Treatment
'Air leakage' message	<ol style="list-style-type: none"> Hose or cuff leaking. Reason: <ul style="list-style-type: none"> – cuff damaged – cuff connector damaged – O-ring damaged or missing – hose double connector damaged Hose and cuff OK. Reason: <ul style="list-style-type: none"> – leakage inside the module – tube disconnected or damaged – air chamber leaking – tubes or valve(s) damaged 	<ol style="list-style-type: none"> Replace cuff <ul style="list-style-type: none"> – replace cuff connector (if the fault is in hose connector, replace hose) – replace O-ring Connect or replace tube <ul style="list-style-type: none"> – replace the whole tubing – fix connections – replace valve(s)
'Unable to measure Sys' message	Systolic blood pressure probably higher than the maximum inflation pressure.	Automatic retrial with increased pressure.
'Cuff occlusion' message	<ol style="list-style-type: none"> Cuff and/or hose occluded. Reason: <ul style="list-style-type: none"> – cuff tube kinked – tube inside module kinked – occlusion inside/outside module Cuff, hose, and tubes OK. Reason: <ul style="list-style-type: none"> – fault in pressure transducer – fault in A/D converter – faulty calibration – missing voltages 	<ol style="list-style-type: none"> <ul style="list-style-type: none"> – straighten tube – remove occlusion <ul style="list-style-type: none"> – replace the NIBP board – check calibration – recalibrate
'Calibration switch on' message	EEPROM protection switch at the bottom of the module is turned to right.	Enables setting the protection OFF in the Calibration menu. Turn switch to left if you are not going to calibrate.
'Calibration not protected' message.	Calibration protection is set to OFF.	Set the protection ON in the NIBP Calibration menu.

4.2 NIBP error code explanation

Code	Explanation
0	RAM failure Memory failure. Change NIBP board.
1	ROM checksum error Memory failure. Change NIBP board.
2	+15V failure Check short circuits. Change NIBP board.
3	-15V failure Check short circuits. Change NIBP board.
4	EEPROM protection switch error. (only with S-STD93) Turn the toggle switch to the left at the bottom of the module.
5	Calibration not protected. (only with S-STD93) Protect calibration by selecting Protection ON in the NIBP calibration menu
6	ADC error ADC circuit failure. Change NIBP board.
7	Watchdog time too short Change NIBP board.
8	Watchdog time too long Change NIBP board.
9	Watchdog activated Change NIBP board.
10	EEPROM checksum error Memory failure. Change NIBP board.
11	Auto zero range exceeded Calibrate NIBP.
12	Communication break Temporal break down of communication from monitor detected. Automatic recovery.
14	Too early Auto Start (needs 25 seconds without pressure).

4.3 Troubleshooting flowchart

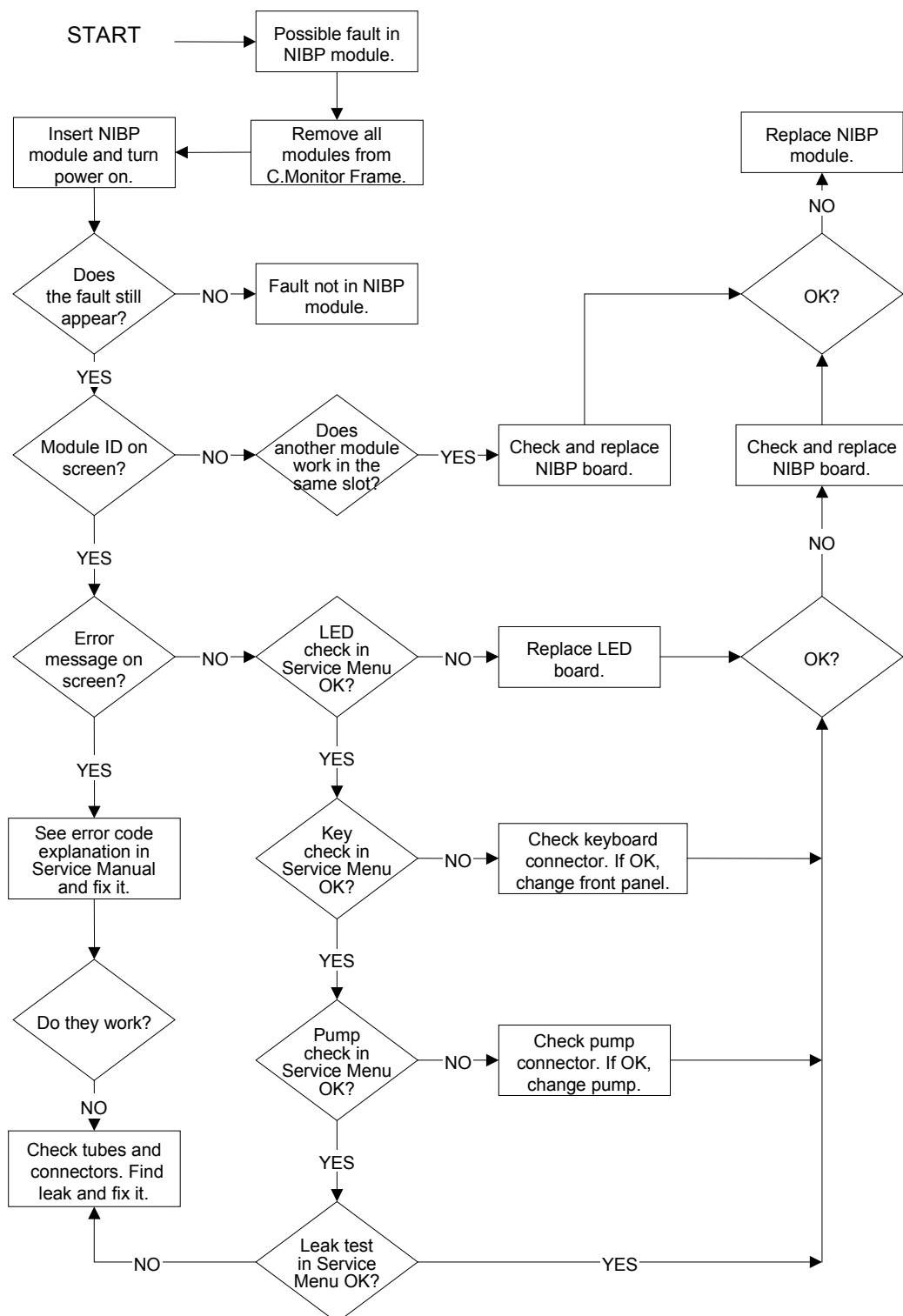
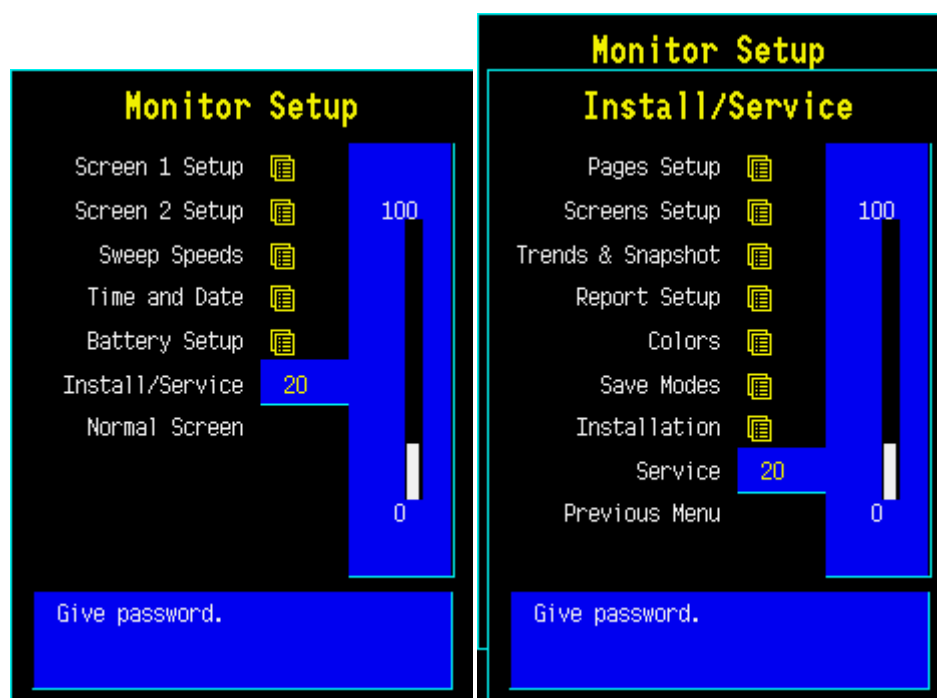


Figure 4 NIBP Module troubleshooting flowchart

5 SERVICE MENU



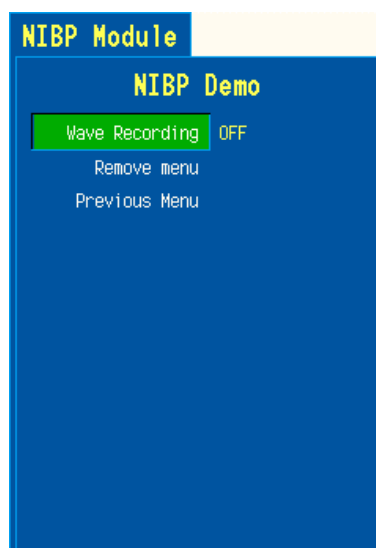
1. Press the **Monitor Setup** key.
2. Select **Install/Service** (password 16-4-34).
3. Select **Service** (password 26-23-8).
4. Select **Parameters - NIBP**.

5.1 NIBP Service menu

NIBP Module		Service Data			
NIBP Demo		Pressure	B1 000000	B2 000000	
Calibrations		Zero	000000	000000	
Safety Valve				AD0	-10
Pulse Valve				AD1	-4
Buttons/Leds				AD2	-3
Pneumatics				AD3	1504
Watchdog				AD4	1
Previous Menu				AD5	-1568
		Protect handle	ON	AD6	5
		Calibr. prot.	ON	AD7	-1479
		+15 V power	OFF		
		Timeouts	0	RAM	OK
		Bad checksums	0	ROM	OK
		Bad c-s by mod	0	EEPROM	OK

- Service Data**
- Pressure** shows measured pressure multiplied by 10.
- Zero** shows pressure at auto zeroing multiplied by 10 and changes between +20 and -20 mmHg. Absolute pressure is the sum of **Pressure** and **Zero**.
- Protect handle** indicates hardware protection for EEPROM memory. It should be ON all the time in normal operation. If it is OFF data can not be read from or written to EEPROM, only the calibration protection can be set or reset by software. It can be turned to OFF by turning the toggle switch to the right at the bottom of the module, which also enables 'Protection ON/OFF' menu selection in the calibration menu.
- Calibr. prot.** shows software calibration protection and should be OFF to enable calibration.
- +15 V power** indicates the condition of the supply voltage +15 Vdirty for the pump and valves. It exists (ON) or not (OFF) depending on service menu function. The supply voltage can be turned on by selecting the previous menu and then the desired menu again.
- AD0 to AD7** show the values of each eight channels of A/D converter.
- Timeouts** is a cumulative number that indicates how many times the module has not responded to the monitor's inquiry. **Bad checksums** is a cumulative number that indicates how many times communication from the module to monitor broke down.
- Bad c-s by mod** is a cumulative number that indicates how many communication errors the module has detected.
- The monitor starts counting these items at power up and resets to zero at power off. The nonzero values do not indicate a failure, but the continuous counting (more than 50 per second) indicates either serial communication failure, or module not in place. Also other modules can cause communication errors that cause these numbers rise.
- RAM** indicates the state of the RAM memory.
- ROM** indicates whether the checksum in the EPROM is in accordance with the one the software has calculated.
- EEPROM** indicates if the values stored in the permanent memory are valid.
- The state is either **OK**, **Fail** or **?** (module not in place or a communication error).

5.1.1 NIBP Demo menu



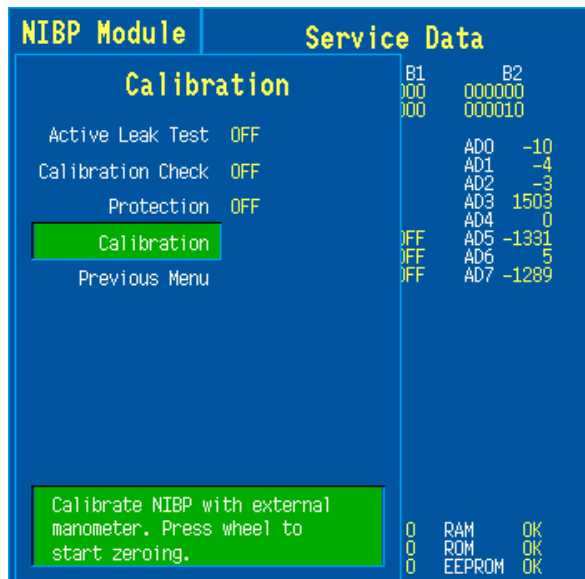
A service menu for demonstrating the oscillometric method of NIBP measurement. The menu shows the realtime pressure signals that are measured from the NIBP cuff. The measurement result is shown in the adjoining digit field.

Wave Recording **Wave Recording** is for selecting the recording option. If ON is selected, the pressure signals are recorded in realtime onto the M-REC paper.

Remove menu **Remove menu** widens the displayed waveform area.

Previous Menu The menu can be closed by selecting the **Previous Menu** or just by pressing the ComWheel if the **Remove menu** was selected.

5.1.2 NIBP Calibration menu



Active Leak Test Wrap an adult cuff around a pipe and connect the cuff to the module. Select the active leak test (ON). The module automatically pumps a pressure of 260 mmHg into the cuff. Wait for several seconds until the pressure stabilizes. Then check that the pressure reading does not drop more than 5 mmHg per minute. If it does, leaking point(s) should be detected and fixed. Cancel the test by selecting Active leak test OFF.

Calibration Check

After the calibration check is selected (ON), manually pump pressure into the module and make sure that the same pressure values are shown both on the display and on manometer. Pressure of both pressure channels B1 and B2 are shown. Note that if the display shows +2 mmHg at zero pressure and if you pumped +200 mmHg into the module, the display should show +202 mmHg.

Protection Software calibration protection (ON/OFF). Select OFF when calibrating. Protection can be set to ON or OFF only when the toggle switch at the bottom of the module is set to the right.

Calibration Calibration selection is available only when protection is OFF.

NIBP calibration can be performed in the NIBP Service menu as follows:

NOTE: Both channels B1 and B2 must be calibrated simultaneously.

1. If **Protection** is ON change it to OFF by first turning the toggle switch to the right at the bottom of the module, which enables the **Protection** selection. Then turn the toggle switch to the left to enable **Calibration**.

NOTE : Do not disconnect the module from the frame when turning the switch. The module must be in the frame during the whole procedure.

NOTE: When the switch is at the right, the NIBP field shows an error message 'Calibration switch on!'.

NOTE: When calibration is enabled, a message 'Calibration not protected' appears.

2. For proper zeroing to take place, remove the hose from the front panel connector. Select **Calibration** and press the ComWheel. Messages 'ZEROING' and 'ZEROED' will appear in the NIBP message field. After this a pressure bar will appear beside the menu.

3. Connect an external mercury manometer with pump to module through the both tubes of the hose. Pump up to about 200 mmHg pressure (range of 150 to 300 mmHg allowed) according to the manometer. Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel.
4. When the values are equal, press the ComWheel to confirm the calibration. First the message 'Calibrating' will appear in the digit field for NIBP followed after a few seconds 'Calibrated', which means that the calibration data has now been saved.
5. Use the bottom switch to enable **Protection** setting and set it ON, and finally disable **Protection** setting.

5.1.3 NIBP Safety Valve menu

Safety Valve		Safety Valve Data	
Start Test		B1	B2
Previous Menu		Pressure	000000 000000
		Zero	000000 000000
			AD0 -30
			AD1 -5
			AD2 -7
			AD3 1169
			AD4 0
			AD5 -1670
			AD6 178
			AD7 -1012
		Protect handle	ON
		Calibr. prot.	ON
		+15 V power	ON
		Max press	B1 0 B2 0
		2 s after stop	0 0
		Timeouts	0 RAM OK
		Bad checksums	0 ROM OK
		Bad c-s by mod	0 EEPROM OK

Start Test **Start test** is for starting and **Stop test** is for stopping the Safety Valve test.

NOTE: Parameter values in Service Data are for reference only.

Safety Valve Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure**, **Zero**, **Protect handle**, **Calibr. prot.**, **+15 V power**, **AD0** to **AD7** as well as **Timeouts** etc.

Max. press and **2 s after stop** show the measured values at Safety Valve test.

Safety Valve Test Adult/Infant

Wrap an adult cuff around a pipe and connect the cuff to the module. Highlight **Start test** and give the ComWheel a press. The test ends automatically or when **Stop test** (appears in place of **Start test**) is pressed.

Max. press indicates the pressure at which the safety valve opens and is normally 310 ± 15 mmHg for adult and $150 \text{ mmHg} \pm 15 \text{ mmHg}$ for infant. **2 s after stop** indicates the pressure at 2 seconds after the pump has stopped and is normally > 280 mmHg for adult and > 120 mmHg for infant. If the value is less, check leakage by the active leak test.

5.1.4 NIBP Pulse Valve menu

Pulse Valve		Pulse Valve Data			
Start Test		Pressure	B1 000000	B2 000000	
Set Valve		Zero	000000	000010	
Previous Menu				AD0	-31
				AD1	-1
				AD2	-6
				AD3	1169
				AD4	0
		Protect handle	ON	AD5	-1508
		Calibr. prot.	ON	AD6	181
		+15 V power	ON	AD7	-1034
				Pulse Valve	50
		Interval 240 mmHg -> 50 mmHg		0	s
		Timeouts	0	RAM	OK
		Bad checksums	0	ROM	OK
		Bad c-s by mod	0	EEPROM	OK

NOTE: Parameter values in Service Data are for reference only.

Start Test **Start test** is for starting and **Stop test** is for stopping the test.

Set Valve **Set Valve** lets you adjust the opening of the pulse valve.

Pulse Valve Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0 to AD7** as well as **Timeouts etc.**

Pulse Valve Checking

Wrap an adult cuff around a pipe and connect the cuff to the module. Select the **Start test** and press the ComWheel. The pressure rises beyond 240 mmHg and stops. The pulse valve opens. The module counts the time it takes for the pressure to go down from 240 mmHg to 50 mmHg and displays it on the screen. The test can be manually stopped by selecting **Stop test**.

The valve can be adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First select Set Valve and press the ComWheel. See the pulse valve value and adjust it by turning the ComWheel. Then press the ComWheel to confirm the value.

The '**Interval 240 mmHg -> 50 mmHg**' time should be less than 60 seconds when the valve is '150' and less than 10 when fully opened (255). When fully closed (0), the system should be airtight and the pressure does not drop. Depending on an individual, the pulse valve may remain closed up to approx. value 45.

If the measured time deviates much from those above, then the pulse valve or its tubes are faulty.

5.1.5 NIBP Buttons/Leds menu

Buttons/Leds		Buttons/Leds Data			
Auto	ON	B1		B2	
Manual	ON	Pressure	000000		000000
STAT	ON	Zero	000010		000010
Measur.	ON			AD0	-11
Previous Menu				AD1	-2
				AD2	-3
				AD3	1503
				AD4	0
		Protect handle	ON	AD5	-1227
		Calibr. prot.	ON	AD6	5
		+15 V power	ON	AD7	-1073
		Auto On/Off	OFF	Set Cycle Time	OFF
		STAT On/Off	OFF	Start Cancel	OFF
		Timeouts	0	RAM	OK
		Bad checksums	0	ROM	OK
		Bad c-s by mod	0	EEPROM	OK

NOTE: Parameter values in Service Data are for reference only.

The front panel LEDs can be turned manually ON and OFF by selecting **Auto ON/OFF**, **Manual ON/OFF**, **STAT ON/OFF**, and **Measur. ON/OFF** from the menu.

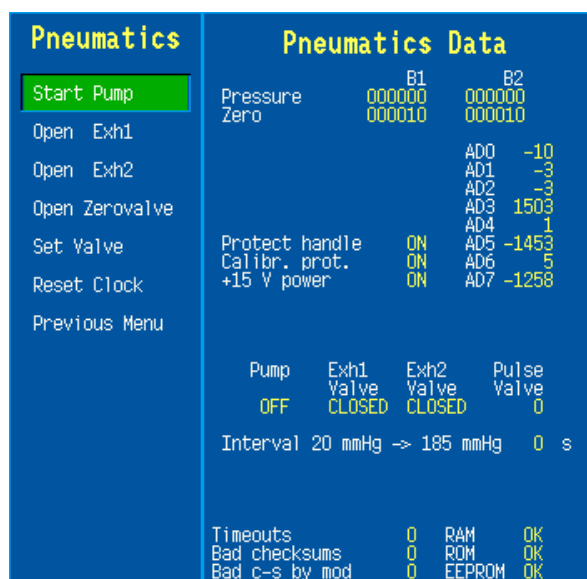
Buttons/Leds Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure**, **Zero**, **Protect handle**, **Calibr. prot.**, **+15 V power**, **AD0** to **AD7** as well as **Timeouts** etc.

Buttons Checking

The front panel keys function is confirmed by pressing the key and observing OFF turns to ON at the corresponding text in the menu.

5.1.6 NIBP Pneumatics menu



NOTE: Parameter values in Service Data are for reference only.

Start Pump/Stop Pump

A manual control for the pump. The selection changes to **Stop Pump** when the pump turns on.

Open Exh1/Close Exh1

A manual control for the exhaust valve 1. The selection changes to **Close Exh1** when the valve is opened.

Open Exh2/Close Exh2

A manual control for the exhaust valve 2. The selection changes to **Close Exh2** when the valve is opened.

Open Zerovalve/Close Zerovalve

A manual control for the zero valve. The selection changes to **Close Zerovalve** when the valve is opened.

Set Valve

With **Set Valve**, the opening of the pulse valve is adjusted between 0 and 255 (0 for fully closed and 255 for fully open). First press the ComWheel, then turn it to adjust the value on screen and finally press to set the value.

Reset Clock

Reset Clock will zero the time on the display.

Pneumatics Data

See NIBP service menu in chapter 5.1 for information on general items **Pressure**, **Zero**, **Protect handle**, **Calibr. prot.**, **+15 V power**, **AD0** to **AD7** as well as **Timeouts** etc.

Pump, **Exh1 Valve**, and **Exh2 Valve** show their states.

Pulse Valve shows how much the valve is opened (0 to 255) during Valve Setting.

Interval 20 mmHg -> 185 mmHg Checking

Select the **Start pump** at different combinations of the valves open/closed and press the ComWheel. The module counts the time it takes for the pressure to go up from 20 mmHg to 185 mmHg and displays it. When all the valves are closed, the pump should be able to pump the pressure in about 1 to 4 seconds into an adult cuff wrapped around a pipe. The pump does not stop without selecting the **Stop Pump** by pressing the ComWheel.

Watchdog BEEP

Connect manometer to the front panel and pump pressure into the module. When the AD5 value changes from negative to positive value (at about 5 mmHg) a beep is heard. This is the watchdog threshold pressure. Beyond this pressure the watchdog is active and cut pressures at about 2 min. (adult).

5.1.7 NIBP Watchdog menu

Watchdog		Watchdog Data			
Test ADULT		Pressure	B1 000000	B2 000000	
Test INFANT		Zero	000000	000000	
Stop Test				AD0	-10
Previous Menu				AD1	-5
				AD2	-3
				AD3	1504
				AD4	1
		Protect handle	ON	AD5	-1216
		Calibr. prot.	ON	AD6	5
		+15 V power	ON	AD7	-1174
		Watchdog Interval 0 s			
		Timeouts	0	RAM	OK
		Bad checksums	0	ROM	OK
		Bad c-s by mod	0	EEPROM	OK

NOTE: Parameter values in Service Data are for reference only.

Test ADULT **Test ADULT** is to test watchdog timer in adult mode (120 to 140 seconds).

Test INFANT **Test INFANT** is to test watchdog timer in infant mode (about 60 to 70 seconds).

Stop Test Stop Test is for stopping the test.

Watchdog Data

See NIBP Service menu in chapter 5.1 for information on general items **Pressure, Zero, Protect handle, Calibr. prot., +15 V power, AD0 to AD7** as well as **Timeouts etc.**

Watchdog Interval shows the time the +15 Vdirty stays on during the test.

Adult watchdog time testing

Select Test ADULT and press the ComWheel. Watchdog interval starts counting up seconds and keeps on counting as long as the +15 Vdirty is on. The time should be 120 to 140 seconds.

Infant watchdog time testing

Select Test INFANT and press the ComWheel. Watchdog interval starts counting up seconds and keeps on counting as long as the +15 Vdirty is on. The time should be 60 to 70 seconds.

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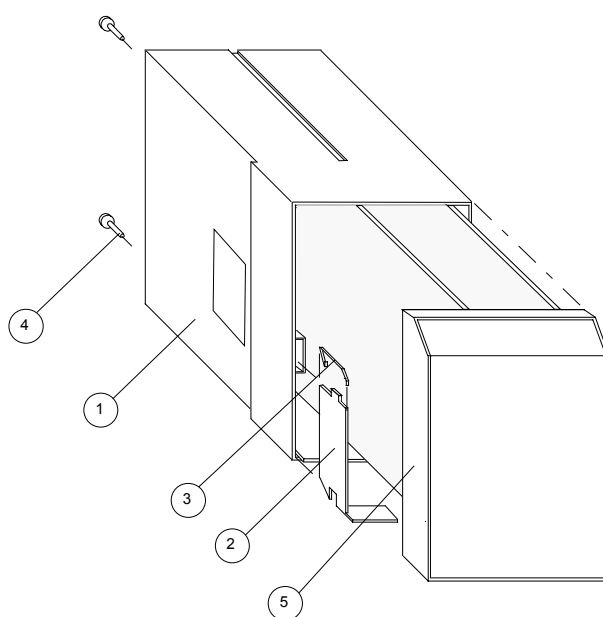
6 SPARE PARTS

6.1 Spare parts list

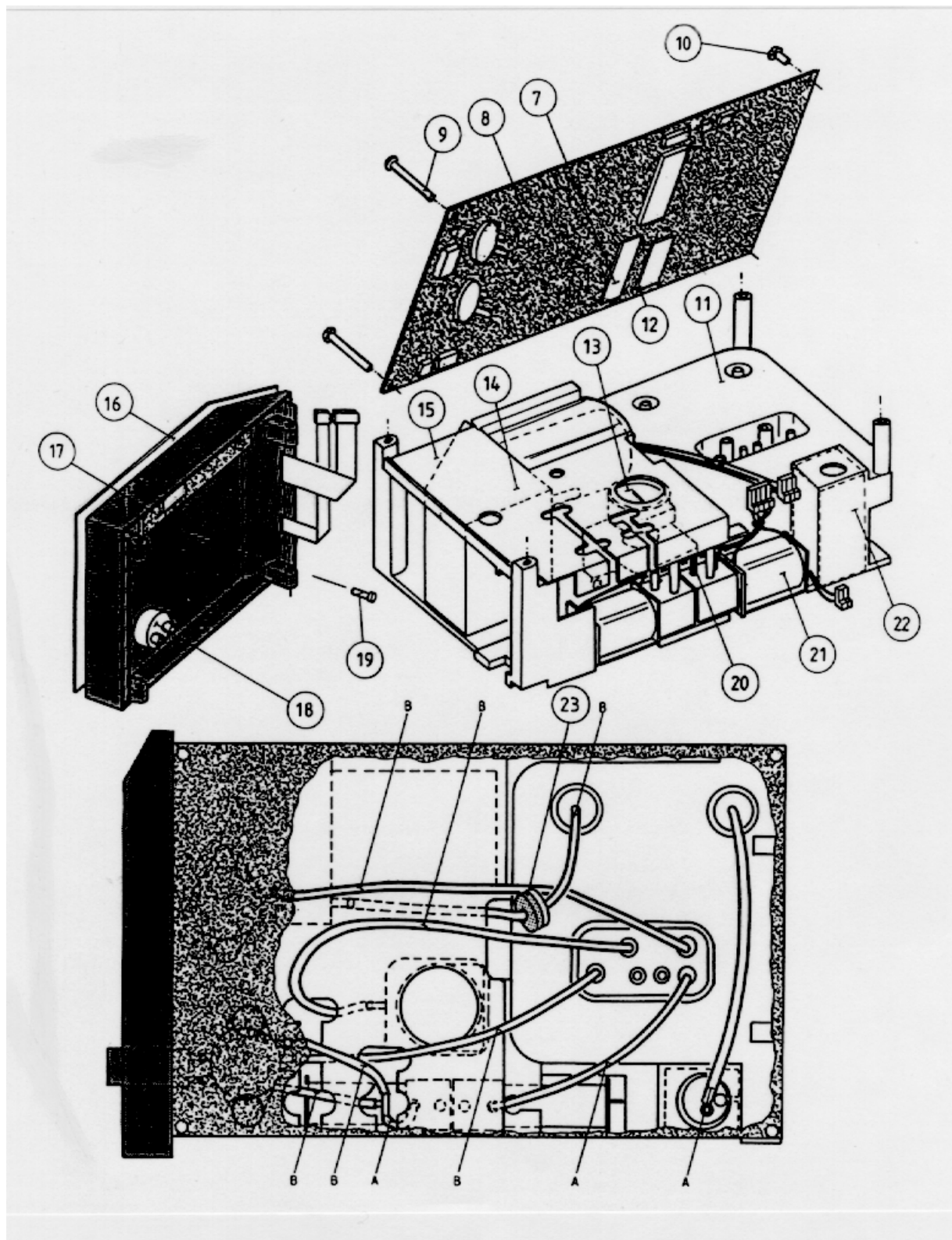
NOTE: Only changed part numbers are listed under later revisions. To find the desired part: check first the list of the revision that corresponds your device. If the part is not listed there, check the previous revision, etc. until you find the right number.

* this part is recommended for stock

6.1.1 NIBP Module, M-NIBP Rev. 01



Item	Item description	Order No.
-	Membrane keypad	879374
1	Module box (wide)	886168
2	Spring pin	879182
3	Latch	879181
4	Cross recess PT screw 3x8 black	628706
5	Front panel unit, M-NIBP (includes all the connectors and input boards)	881335



Item	Item description	Order No.
8	NIBP board, M-NIBP (Rev. 01)	*(880359) Use 883011 1) 883902
9	Cross cylinder-head PT screw 3x20	628709

Item	Item description	Order No.
10	Cross cylinder-head PT screw 3x10	628703
11	NIBP frame, M-NIBP	880427
13	Safety valve (overpressure valve)	877109
14	NIBP pump, M-NIBP (Rev. 01-02)	*(880363) Use 883346
15	Plastic pump cover, M-NIBP	879176
16	Front panel sticker	see 6.1.5
17	LED board, M-NIBP (Rev. 01-03)	880361
18	Hose connector	64654
19	Cross cylinder-head screw M2.5x6	628700
20	Port plug for magnetic valve	58535
21	Magnetic valve	*58534
22	Pulse valve	*880365

6.1.2 NIBP Module, M-NIBP Rev. 02

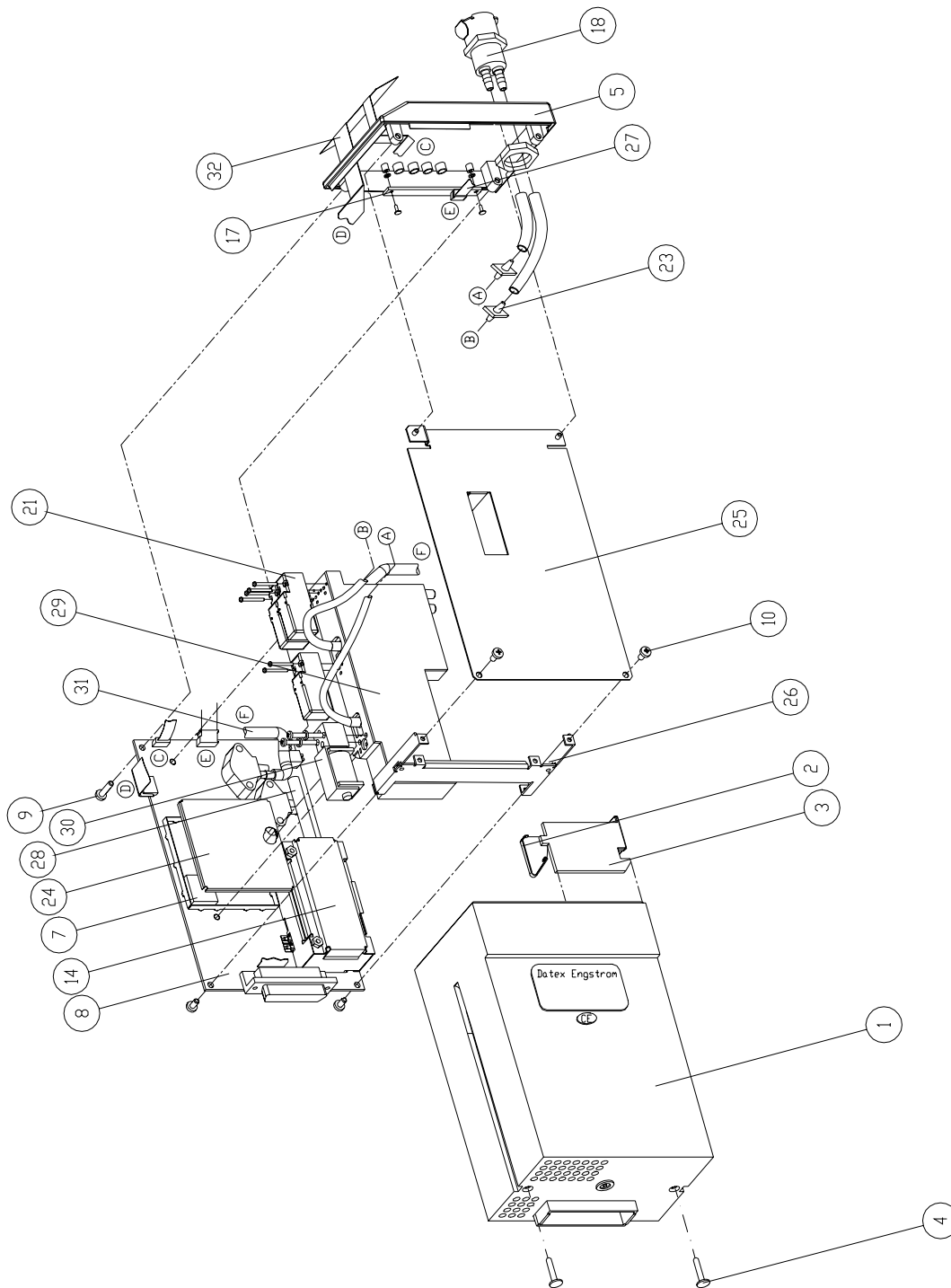
Item	Item description	Order No.
8	NIBP board, M-NIBP (Rev. 02)	*(882418) Use 883011 ¹⁾ 883902
23	Check valve	58542

¹⁾ NOTE: The NIBP board 883011 can be used as a replacement only with NIBP software 883902.

6.1.3 NIBP Module, M-NIBP Rev. 03

Item	Item description	Order No.
-	NIBP software	*883902
8	NIBP board, M-NIBP (Rev. 03)	*883011
14	NIBP pump, M-NIBP (Rev. 03)	*883346

6.1.4 NIBP Module, M-NIBP Rev. 04



Item	Item description	Order No.
4	Cross recess screw M3×8 black	616215
8	NIBP board, M-NIBP (Rev. 04)	*894368

Item	Item description	Order No.
9	Screw STZN 3.5×9.5 DIN 7981	62539
10	Cross cylinder-head screw M3×6	61721
14	NIBP pump, M-NESTPR, M-NIBP (Rev. 04)	*889993
17	LED board, M-NIBP (Rev. 04)	893882
21	Magnetic valve	58562
24	EMC cover	888236
25	Support plate	893881
26	Metal frame	888230
27	Flat cable; LED	894118
28	NIBP pump filter	*57142
29	Damping chamber, M-NESTPR, M-NIBP (Rev. 04)	888240
30	Bleed valve, M-NESTPR, M-NIBP (Rev. 04)	58566
31	Spring	892676
-	Check valve	58542

6.1.5 NIBP Module, M-NIBP Rev. 05

No new spare parts.

6.1.6 Front panel stickers for AS/3 modules (square buttons)

Front panel stickers that are related to the Compact Module type and adaptation:

Adaptation codes: DA=Danish, DE=German, EN=English, ES=Spanish, FI=Finnish, FR=French, IT=Italian, JA=Japanese, NL=Dutch, NO=Norwegian, PT=Portuguese, SV=Swedish

Item no. 16

Adaptation	M-NIBP (Rev. 00-04) Order no.
DA	892215
DE	880476
EN	879482
ES	884386
FI	888872
FR	880159
IT	886752
JA	888316
NL	886124
NO	893559
PT	895254
SV	885870

6.1.7 Front panel stickers for S/5 modules (round buttons)

Front panel stickers that are related to the Compact Module type and adaptation:

Adaptation codes: DA=Danish, DE=German, EN=English, ES=Spanish, FI=Finnish, FR=French, IT=Italian, JA=Japanese, NL=Dutch, NO=Norwegian, PT=Portuguese, SV=Swedish

Adaptation	M-NIBP (Rev.05) Order no.
DA	898609
DE	898600
EN	898599
ES	898603
FI	898606
FR	898601
IT	898604
JA	898606
NL	898602
NO	898608
PT	898605
SV	898607

7 EARLIER REVISIONS

For service information on the earlier revisions, please refer to:

NIBP Module revision 01 Service Manual p/n 880850

NIBP Module revision 02 Service Manual p/n 882580

NIBP Module revision 03 Technical Reference Manual p/n 892953

APPENDIX A

SERVICE CHECK FORM

Non-Invasive Blood Pressure Module, M-NIBP

Customer			
Service	Module type	S/N	
Service engineer		Date	



OK = Test OK



N.A. = Test not applicable



Fail = Test Failed

	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	2. External parts	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>
3. Pump's filter	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	4. Installation	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>
Notes 							

5. Recognition	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>				
6. Module software	NIBP						
7. Communication and memories	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	8. LEDs and membrane keys	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>
9. Pump and valves	<input style="border: 1px solid green;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>	<input style="border: 1px solid red;" type="checkbox"/>				
10. Leak test					≤ 5 mmHg/min		
11. Calibration check							
	Measured B1	Measured B2	Allowed range				
0 mmHg			±10 mmHg				
100 mmHg			100 + z.o. ±2 mmHg				
200 mmHg			200 + z.o. ±3 mmHg				
260 mmHg			260 + z.o. ±4 mmHg				
z.o. = zero offset at 0 mmHg pressure							
12. Watchdog timer activation pressure					9...19 / 5...10 mmHg		

13. Watchdog timer			
			Allowed range
Adult			120...140 s
Infant			60...70 s

14. Safety valve	B1	B2	Allowed range
'Max press' ADULT			290...330 mmHg
'2 s after stop' ADULT			290...330 mmHg
'Max press' INFANT			154...165 mmHg
'2 s after stop' INFANT			154...165 mmHg

	OK	N.A.	Fail		OK	N.A.	Fail
15. Cuff related messages	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	16. Adult cuff detection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17. Test measurement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	18. Infant cuff detection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Notes _____							

19. Electrical safety check	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	20. Functioning after electrical safety check	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. Final cleaning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
Notes _____							

Notes	_____

Used Spare Parts	_____
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Signature	_____
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