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Medical Equipment Troubleshooting Flowchart Handbook

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Engineering World Health

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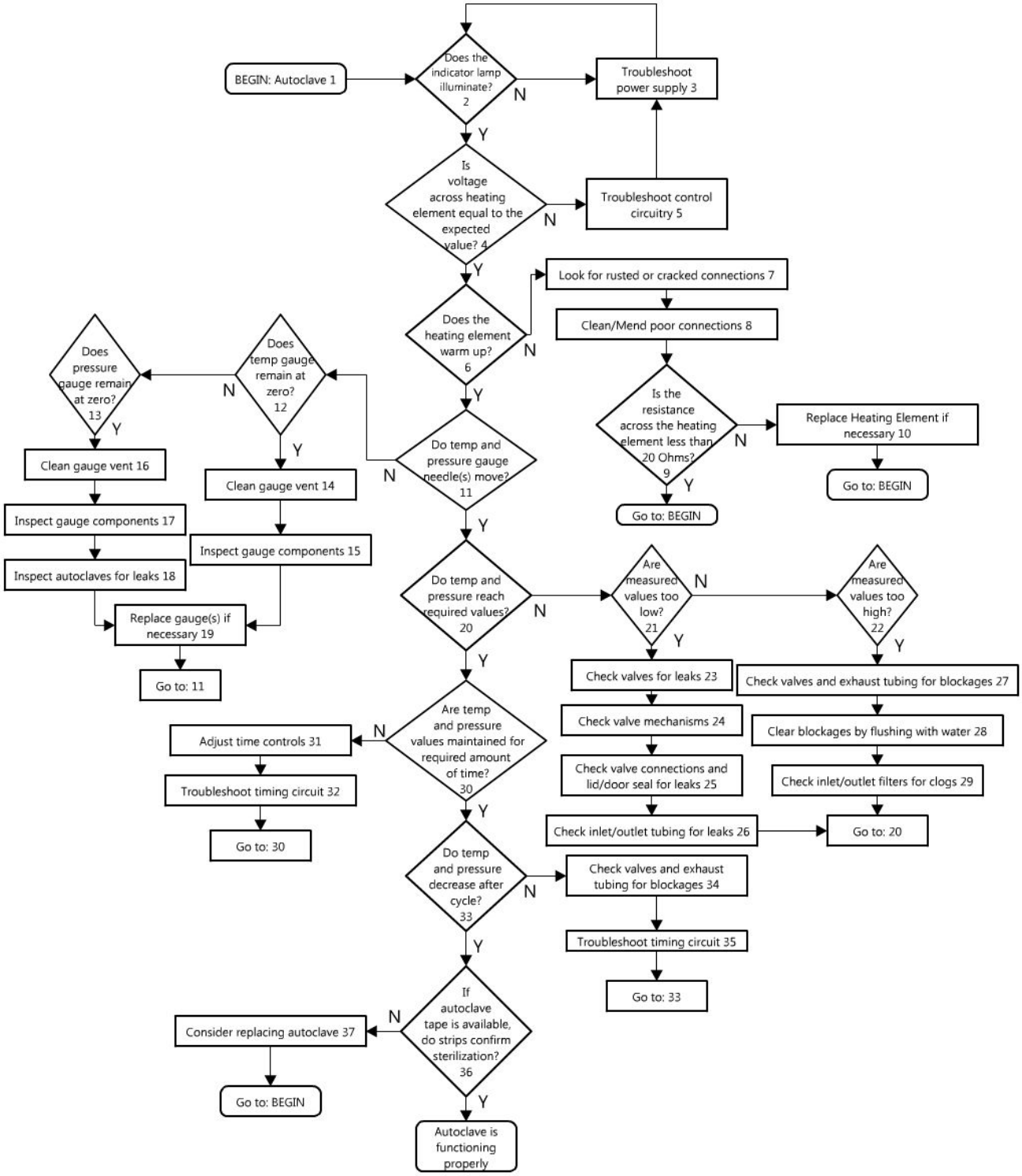
Autoclave

Flowchart



Description

#	Text Box	Comments
1	Begin: Autoclave	Start the diagnostic process for a work order on an autoclave
2	Does the indicator lamp illuminate?	Provide appropriate power supply to the autoclave and observe indication that the device turns on
3	Troubleshoot power supply	If the device is connected to power but does not turn on, there is a problem with the power supply. This could be a problem with the wiring or connections within the device. See BTA skills on Power Supply
4	Is voltage across heating element equal to the expected value?	Use a multimeter to test the wires leading to the heating element to determine if it is receiving the expected voltage (wall voltage)
5	Troubleshoot control circuitry	If the device is receiving power but improper voltage is reaching the heating element, there is likely a problem with the control circuit. Ensure that all settings are what they should be for normal autoclave function
6	Does the heating element warm up?	Attach autoclave to power with lid open and observe whether the heating element begins to get hotter
7	Look for rusted or cracked connections	Examine connections involved with the heating element to determine whether they are adequate for proper functionality
8	Clean/Mend poor connections	See BTA skills on Connections
9	Is the resistance across the heating element less than 20 Ohms?	Use a multimeter across the heating element to determine its total resistance
10	Replace heating element if necessary	If the resistance across the heating element is greater than 20 Ohms, it needs to be replaced. To replace the wire within the element, nichrome wire must be used. See BTA skills on Heating Element
11	Do temp and pressure gauge needle(s) move?	While autoclave runs cycle, observe motion of temperature and pressure gauge(s). There must be displayed values for BOTH parameters to advance from this step
12	Does temperature gauge remain at zero?	Determine if value of zero is given for temperature despite temperature increase
13	Does pressure gauge remain at zero?	Determine if value of zero is given for pressure when pressure is expected to have increased
14	Clean gauge vent	If the gauge works but does not move during autoclave cycle, then the vent leading to the gauge input may be blocked. Flush vent with distilled water to remove blockage. CAUTION: do not submerge gauge in water. See BTA skills on Blockage
15	Inspect gauge components	If the cycle runs but the needle in the gauge doesn't move, there is a problem with the gauge. Remove gauge from autoclave and examine interior. Gently manipulate the gauge to mimic response to rising temperature and pressure within the device. If the needle can be made to move easily and smoothly, then the gauge components are functional

16	Clean gauge vent	If the gauge works but does not move during autoclave cycle, then the vent leading to the gauge input may be blocked. Flush vent with distilled water to remove blockage. CAUTION: do not submerge gauge in water. See BTA skills on Blockage
17	Inspect gauge components	If the cycle runs but the needle in the gauge doesn't move, there is a problem with the gauge. Remove gauge from autoclave and examine interior. Gently manipulate the gauge to mimic response to rising temperature and pressure within the device. If the needle can be made to move easily and smoothly, then the gauge components are functional
18	Inspect autoclave for leaks	Examine all parts of autoclave to find any leaks. Visually inspect for steam escaping from autoclave. See BTA skills on Leaking
19	Replace gauge(s) is necessary	If the gauge needle cannot be made to move as described in #15 and #17, then the gauge is likely broken and may need to be replaced
20	Do temperature and pressure reach required values?	Verify that interior of autoclave reaches temperature and pressure values required to achieve sterilization Common temperature values: 121˚C for 15 minutes, 134˚C for 3 minutes
21	Are measured values too low?	Determine if the autoclave reaches temperature and pressure values below those required for sterilization by reading the gauge values.
22	Are measured values too high?	Determine if the autoclave reaches temperature and pressure values above those required for sterilization by reading the gauge values.
23	Check valves for leaks	Visually inspect closed valves throughout cycle. If air escapes closed valve, then there is a leak in the valve that must be mended. See BTA skills on Leaking
24	Check valve mechanisms	Check functionality of valve components by ensuring that they are able to open and close smoothly
25	Check valve connections and lid/door seal for leaks	Examine points at which valves connect to autoclave to ensure that they are adequately sealed If autoclave door/lid has a metal-to-metal seal, lubricate seal If autoclave door/lid has a gasket seal, determine adequacy of gasket. If gasket is dry or cracked, it needs to be replaced See BTA skills on Seals
26	Check inlet/outlet tubing for leaks	Visually examine autoclave tubing for leaks. See BTA skills on Leaking
27	Check valves and exhaust tubing for blockages	Open valves and ensure that air can pass through them. Also verify that exhaust tubing is unobstructed. See BTA skills on Blockages
28	Clear blockages by flushing with water	If any blockages are found, flush the blocked components with distilled water to remove blockages. See BTA skills on Blockage
29	Check inlet/outlet filters for clogs	Examine autoclave filters for clogs. If clogs are found, clean or replace filter(s). See BTA skills on Filters
30	Are temperature and pressure values maintained for required amount of time?	Determine if the sterilization temperature and pressure values are maintained for enough time to sterilize autoclave contents
31	Adjust time controls	Ensure that time is on correct setting Common times: 121˚C for 15 minutes, 134˚C for 3 minutes

32	Troubleshoot timing circuit	If settings are correct, but autoclave does not maintain required temperature and pressure values for proper duration, there is a problem with the circuit controlling the timing of the cycle. Examine this circuit for broken or damaged connections and components. See BTA skills on Electrical Simple
33	Do temperature and pressure decrease after cycle?	Ensure that the temperature and pressure within the autoclave decrease after the completion of the sterilization cycle by observing the decrease in the measured values displayed on the device
34	Check valves and exhaust tubing for blockages	Note steam escape from open valves to ensure that they are not blocked If temperature and pressure values do not decrease after the completion of the autoclave cycle, it could be due to a blocked exhaust tube. See BTA skills on Blockages
35	Troubleshoot timing circuit	If settings are correct, but autoclave does not maintain required temperature and pressure values for proper duration, there is a problem with the circuit controlling the timing of the cycle. Examine this circuit for broken or damaged connections and components. See BTA skills on Electrical Simple
36	If autoclave tape is available, do strips confirm sterilization?	Run test cycle with autoclave test tape to verify that sterilization is achieved. If tape is not available, biological indicators can also be used for sterilization.
37	Consider replacing autoclave	Autoclave may be beyond repair. Discontinue autoclave use or refer to specialist

Note about autoclave tape:

- Autoclave tape is an adhesive used to indicate whether a specific temperature and pressure have been reached
- Strips of this tape are applied to items before they are placed into the autoclave
- The tape has diagonal markings that will change color when the target temperature and pressure are achieved
- If the tape markings are still their original color after going through the autoclave cycle, then the autoclave did not reach the temperature and pressure required for sterilization
- Biological indicators can be used to monitor the sterilization of an autoclave, by testing its capability to kill microorganisms. Only *Bacillus stearothermophilus* spores can be used to monitor the effectiveness of steam autoclaves.
- A biological indicator system consists of the growth medium with spores and indicator dye. After autoclaving the indicator, it has to be incubated at 56°C for up to three days. Any signs of turbidity (indicating growth) indicate the autoclave did not function properly.

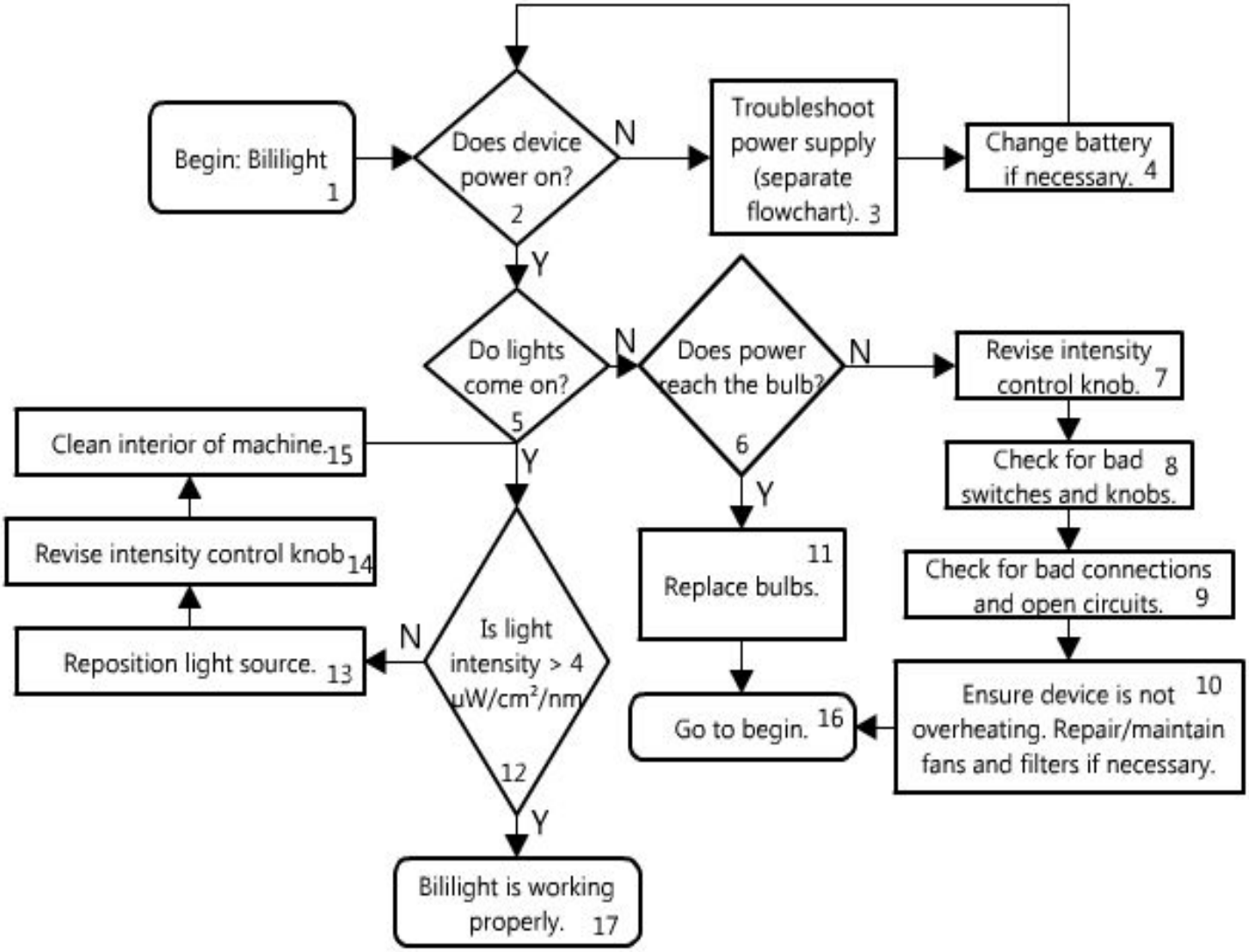
Preventive Maintenance

- After each use: Clean the inside of the autoclave and around valve and vents
    - Empty all water from chamber and thoroughly dry
    - Wipe off metal-to-metal seal with clean towel to remove build-up
- Make sure valves are not clogged
    - Periodically clean control valve with hot, soapy water
- Check air exhaust tube by flushing water through it to make sure it is not blocked.
- Descale the chamber: most effective to use detergent meant for lime scale removal. Vinegar diluted with distilled water can also be used.
- Check for signs of wear and damage. Ensure sufficient seal around lid:
    - For a metal-to-metal seal, lubrication of the seal must be maintained
    - For a gasket seal, the seal must be pliable. If it is cracked or dry, then it should be replaced
- Valve safety check: Test the safety pop-off any time there is pressure built up in the sterilizer. Test the valve below the operating pressure with the use of a screwdriver to pop the pressure relief valve. Make sure your hand is away; otherwise the steam can cause burns.

Thoughts/ Comments/ Ideas

Bililight

Flowchart



Description

#	Text Box	Comments
1	Begin: Bililight	Start the diagnostic process for a work order on a bililight.
2	Does device power on?	Displays, lights, and sounds are all indicators that the device has turned on.
3	Troubleshoot power supply (separate flowchart).	Most bililights have an AC-DC power supply. See Flowchart for Power Supply, and BTA Skills for Power Supply
4	Change battery if necessary.	Some bililights may have a battery. See BTA skills on Batteries.
5	Do lights come on?	Do the blue lights illuminate when they are switched on?
6	Does power reach bulb?	Use a voltmeter to determine whether the appropriate voltage reaches the bulb input.
7	Revise intensity control knob.	Make sure any intensity control knob is turned up to allow the lights to illuminate.
8	Check for bad switches and knobs.	Review switches and potentiometers for faults. See BTA skills on Switches.
9	Check for bad connections and open circuits	Open circuits, bad connections, and bad wires can prevent the lights from illuminating. See BTA skills on Connections.
10	Ensure device is not overheating. Repair/maintain fans and filters if necessary.	Some bililights have a safety mechanism that turns the lights off when the device overheats. If this is the case, try allowing the device to cool before attempting to turn the lights on again. If this was the problem, consider ways to improve ventilation.
11	Replace bulbs.	If the appropriate voltage reaches the bulbs and they do not illuminate, the bulbs must be replaced.
12	Is light intensity > $4\mu W/cm^2/nm$	Measure the light output at patient-level. $4\mu W/cm^2/nm$ is the minimum output for a bililight, though many have outputs higher than this (e.g. $15\mu W/cm^2/nm$)
13	Reposition light source.	If the intensity is too low, the light source may be positioned too far from the patient.
14	Revise intensity control knob.	The light intensity might be increased by manipulating the intensity control knob.
15	Clean interior of machine.	If the interior of the machine or the bulbs are dirty, it might obstruct the light source or cause overheating of the device.
16	Go to begin.	Start the diagnostic process again to see if the corrective measures have solved the problem.
17	Bililight is working properly.	The light intensity is above the minimum, and the device can be used with patients.

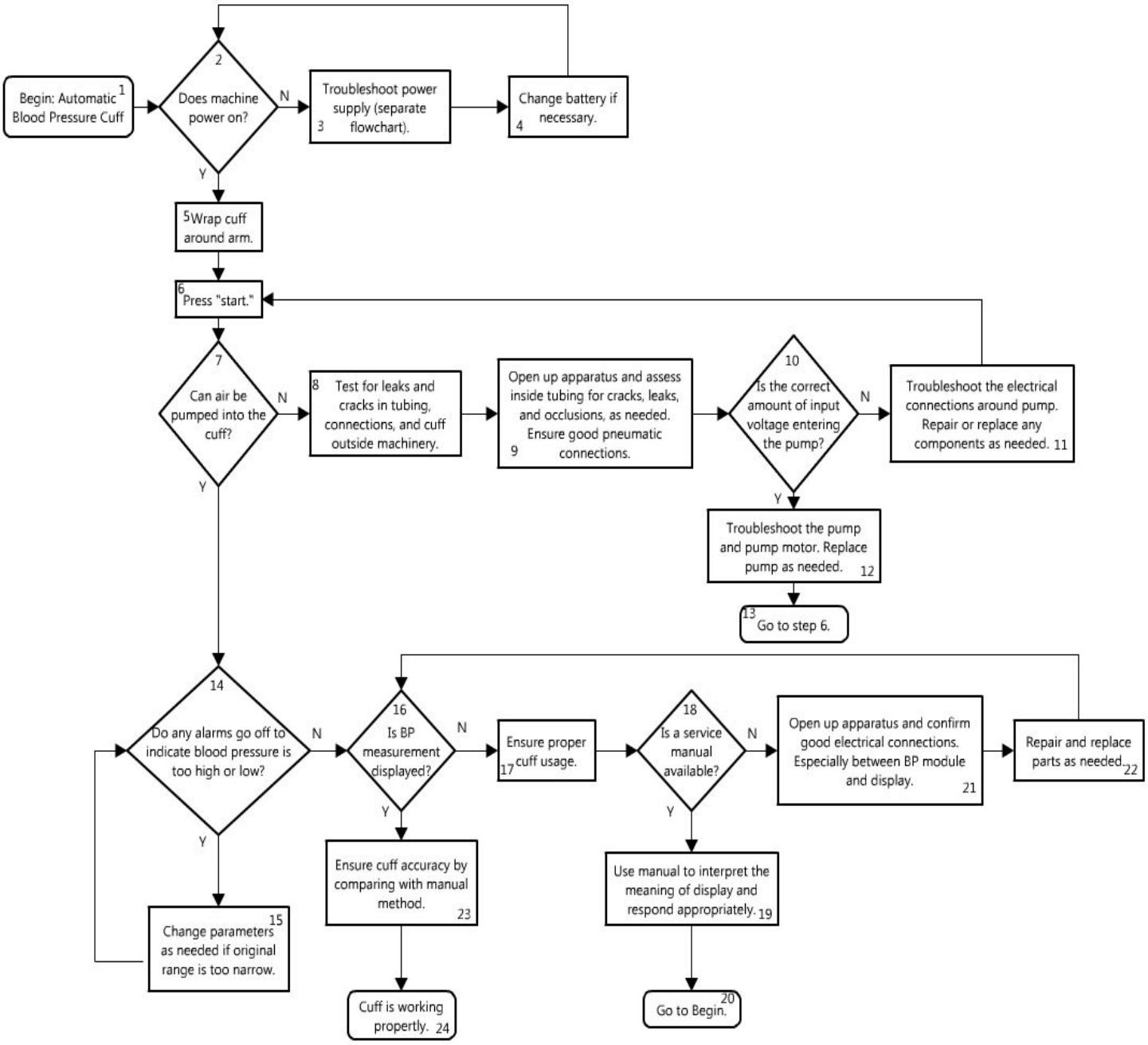
Preventive Maintenance

- Check for signs of physical damage or abuse
- Check for evidence of fluid spills
- Check AC plug/cord/receptacle
- Check strain relief at both ends of cord
- Check controls/switches
- Check power-on sequence
- Check for unusual noise or vibration
- Clean interior/exterior as required
- Test all audible & visual alarms and indicators
- Measure chassis ground resistance
- Measure chassis leakage current
- Clean air filter
- Electrical safety
- Measure light output

Thoughts/ Comments/ Ideas

Blood Pressure Monitor (Automatic)

Flowchart



Description

#	Text Box	Comments
1	Begin: Automatic Blood Pressure Cuff	Testing and maintenance is advised when the automatic blood cuff fails to give out a complete or accurate blood pressure.
2	Does machine power on?	Lights, displays, and sounds are signs that the device is powered on.
3	Troubleshoot power supply (separate flowchart).	NIBP (Noninvasive Blood Pressure) machines have varying sources of power. Some require batteries, and others can be plugged directly into the wall. It is always best to ensure that the proper power is being administered. Machines requiring 110-120V, for example, should not be plugged into a socket with a power of 220-240V without the proper transformer. See Flowchart on Power Supply, or BTA skills on Power Supply.
4	Change battery if necessary.	If batteries are required, test that they are able to receive and hold a charge. See BTA skills on Batteries.
5	Wrap cuff around arm.	Try wrapping cuff around your arm before beginning function test. NIBP will require either pulses or vibrations brachial artery, so it is important that the cuff is on correctly. Follow the **User Guide** for more detailed instructions.
6	Press "start.”	For some machines, a flashing light or image will suggest the machine is ready to begin the blood pressure measurement.
7	Can air be pumped into the cuff?	Once engaged, the machine’s pump will begin inflating the cuff. Does the cuff readily inflate? Is a reading able to be obtained?
8	Test for leaks and cracks in tubing, connections, and cuff outside machinery.	Use BTA skills on Connections, Leaks and Blockages to assess for cracks, leaks, or occlusions.
9	Open up apparatus and assess inside tubing for cracks, leaks, and occlusions, as needed.	If cuff still has difficulty inflating, carefully open the apparatus and observe what happens to inside tubing when the pump is activated. Listen for escaping air and use BTA skills on Connections, Leaking, Seals and Blockages to assess, replace, repair, or clean tubing and parts as needed.
10	Is the correct amount of input voltage entering the pump?	Test the voltage going into the pump using a multimeter. Compare the measured voltage to the required DC input voltage, which can usually be found as a marking somewhere on the pump.
11	Troubleshoot the electrical connections around pump. Repair or replace any components as needed.	If the pump is not receiving the proper input voltage, this has something to do with the electrical circuitry or connections supplying power to the pump. Use BTA skills on Electrical Simple to observe, assess, and repair any circuit components and connections.
12	Troubleshoot the pump and pump motor. Replace pump as needed.	If the pump is receiving the proper input voltage, but still not properly inflating the cuff, try troubleshooting the pump and its motor using BTA skills on Motors and Mechanical. Pump may have to be replaced if irreversibly damaged.
13	Go to step 6.	Restart cuff inflation to see if the corrective measures have repaired the machine.
14	Do any alarms go off to indicate blood pressure is too high or low?	Some NIBP machines are equipped with alarms that indicate whether or not a blood pressure is within an acceptable healthy range, preset by the machine’s parameters.
15	Change parameters as needed if original range is too narrow.	If machine parameters are causing alarms to go off when a healthy blood pressure is causing the alarms to go off, it may be possible to change them. Check parameters by pressing the “menu” button, if applicable. Consult with clinical staff to see how these parameters should be set.

16	Is BP measurement displayed?	After pressing start, is a numerical value for blood pressure displayed? NIBPs will usually display a systolic, diastolic, and pulse rate after measurement.
17	Ensure proper cuff usage.	Is the cuff the proper size for your arm or the patient's arm? Are the leads in the cuff over the brachial artery? NIBPs can be very sensitive. Check the **User Guide** to ensure proper machine usage.
18	Is a service manual available?	Many service manuals will instruct the user on the meaning of displayed error messages for the specific NIBP system. These messages can also point to general areas of the device that can be troubleshot using the relevant BTA skills.
19	Use manual to interpret the meaning of display and respond appropriately.	Most of the time these messages are accompanied by a proposed set of actions.
20	Go to Begin.	Restart diagnostic process to see if the corrective measures have repaired the machine.
21	Open up apparatus and confirm good electrical connections. Especially between BP module and display.	Sometimes a problem in the circuit is to blame for inaccurate or incomplete measurements. Use BTA skills on Electrical Simple to observe, assess, and repair any circuit components and connections.
22	Repair and replace parts as needed.	If there is any obvious damage, repair connections and replace necessary parts using the appropriate BTA skills.
23	Ensure cuff accuracy by comparing with manual method.	After obtaining a blood pressure measurement, have the clinical staff take a blood pressure on the same individual using a working manual blood pressure cuff. A good NIBP will be within 5 mmHg, but ultimately it is up to the staff whether or not the cuff should be used on patients.
24	Cuff is working properly.	Return apparatus to appropriate clinical staff.

Preventive Maintenance

- Check power supply. If the machine uses batteries, check their voltage and replace when output is low. If wall input is utilized, ensure that the proper power is being used.
- Inspect power cords and plugs. Check AC plug for loose or damaged parts. Verify proper insulation and integrity of cords.
- Assess for leaks, cracks, and occlusions in the cuff, connections, and tubing inside and outside apparatus. Inspect all fittings and connectors.
- Inspect inside circuitry. Verify that all switches operate properly as well.
- Check that any alarms go off when the measured blood pressure is outside of an acceptably healthy, that is if the NIBP has this capability. The clinical staff should establish this range. To test this on yourself, set the parameters such that they should go off when you take your own blood pressure. Once you are assured that the alarms are functional, be sure to set the parameters back!
- Perform a self-test on the BP cuff to ensure cuff is working properly and within reasonably accuracy (±5 mmHg). Accuracy can be determined by having the clinical staff take your blood manually.

How To: Taking Blood Pressure

1. Prepare the patient.
    - Sitting or lying down
    - Arm unobstructed
    - Ask about blood pressure history
    - Ensure that it is a quiet space and that the patient doesn't move too much – many NIBPs are sensitive to noise and movement
2. Wrap the cuff around the upper arm with leads facing the brachial artery. Be sure that it is the proper cuff size for the patient's arm. The cuff should be about 1-2 cm above the elbow and about level with the patient's heart.
3. Turn on the machine, and press "start" when ready to measure blood pressure.
4. Have the patient remain still and quiet until a blood pressure is displayed. Often times a pulse rate will also be measured and displayed.
5. If the patient has a higher than usual blood pressure, many NIBPs will allow the user to hold the start button until the monitor inflates 30-40 mmHg higher than the expected blood pressure.
6. If the cuff needs to be deflated or reset during inflation for any reason, press the off button.
7. Record the blood pressure.

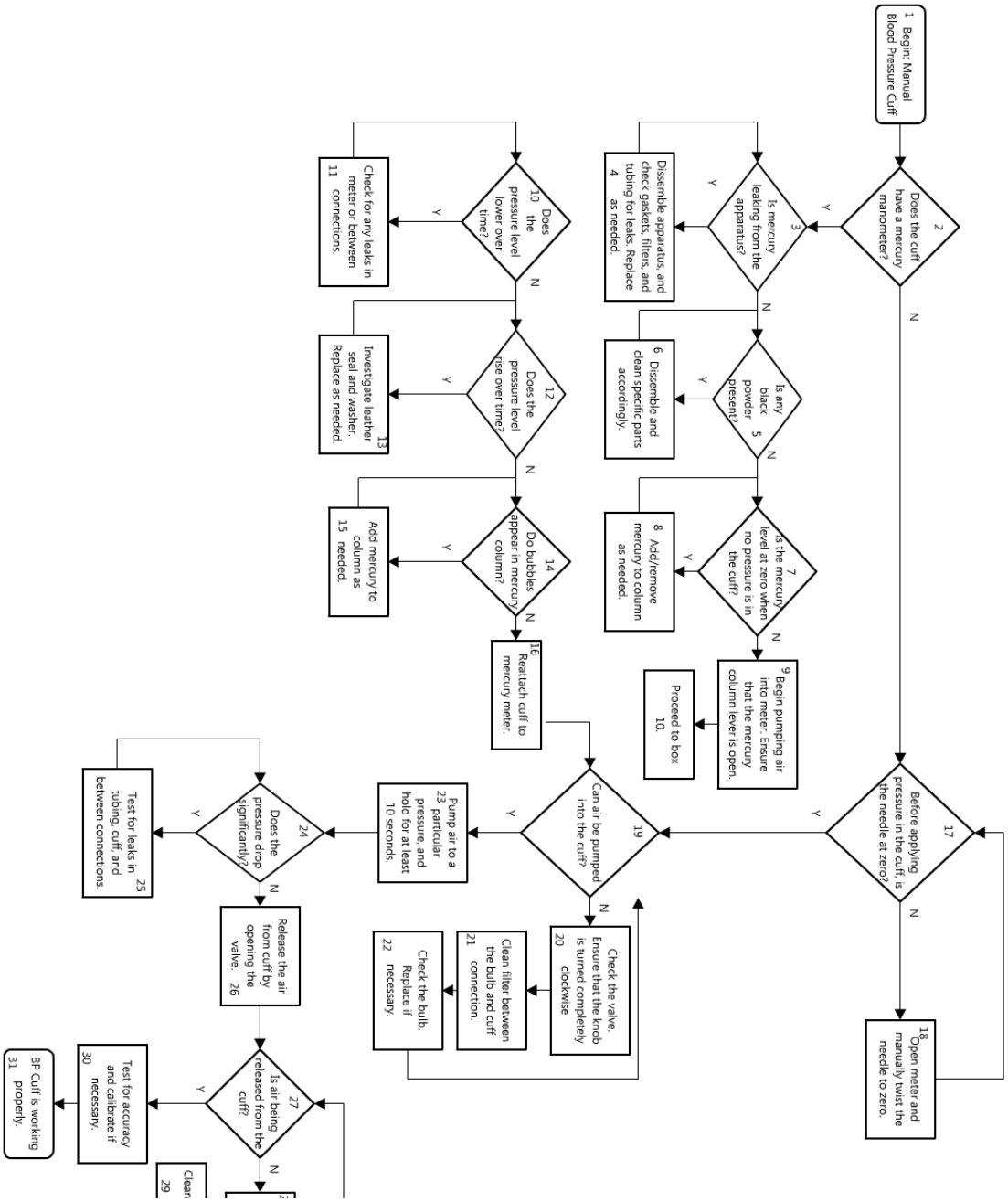
<u>Examples of ranges for healthy blood pressures:</u>

Age	**BP (Systolic/ Diastolic)**
Child, <6 months	90-105/70
Child, 6 months to 7 years	105-117/70
Adult	120/80

Thoughts/ Comments/ Ideas

Blood Pressure Monitor (Manual)

Flowchart



Description

#	Text Box	Comments
1	Begin: Manual Blood Pressure Cuff	Testing and maintenance is advised when the manual cuff fails to give out a complete or accurate blood pressure.
2	Does the cuff have a mercury manometer?	There are two types of manual blood pressure cuffs, one with a mercury manometer and an aneroid sphygmomanometer with just a small pressure dial.
3	Is mercury leaking from the apparatus?	If there is any mercury escaping the reservoir, proceed with extreme caution and **follow mercury-handling protocols.** See BTA skills for Leaking and Blockages.
4	Disassemble apparatus and check gaskets, filters, and tubing for leaks. Replace as needed.	Disassemble the apparatus (follow protocol below).Assess each part for any leaks and cracks. Replace or repair faulty parts as necessary. See BTA skills on Plumbing and Mechanical.
5	Is any black powder present?	The black powder is oxidized mercury and needs to be removed.
6	Disassemble and clean specific parts accordingly.	Disassemble the apparatus (follow protocol below) If oxide is in rise tube and mercury tank: -Using a stiff wire, push a small piece of cotton or gauze through the rise tube several times -Gently tap mercury tank (with opening facing downwards) onto tray to make sure all mercury has been removed -Wash tube and tank in a detergent and water solution -Dry thoroughly -Clean mercury using protocol below
7	Is the mercury level at zero when no pressure is in the cuff?	Meter should be at zero when no pressure is applied.
8	Add/remove mercury to column as needed.	**Follow mercury-handling protocol.** Any added mercury can be taken from another existing meter that doesn't work correctly or isn't in use.
9	Begin pumping air into meter. Ensure that the mercury column lever is open.	If possible, disassemble tubing, and attach the bulb and its tubing to the meter so that the cuff is not involved in meter testing. Be sure that the mercury column lever is open, or else no mercury will come up the rise tube.
10	Does the pressure level lower over time?	The mercury level will fall if there are any cracks or leaks.
11	Check for any leaks in meter or between connections.	Use BTA skills on Leaking and Seals to assess for cracks or leaks.
12	Does the pressure level rise over time?	Leather seal and washer may be cracked/broken.
13	Investigate leather seal and washer. Replace as needed.	Use BTA skills to assess for cracks or leaks. Leather seal and washer will usually need to be replaced. See BTA skills on Leaking, Seals and Connections.
14	Do bubbles appear in mercury column?	Small air pockets will form if not enough mercury is in the tank.
15	Add mercury to column as needed.	**Follow mercury-handling protocol.** Any added mercury can be taken from another existing meter that doesn't work correctly or isn't in use.
16	Reattach cuff to mercury meter.	Reassemble cuff to meter if the apparatus was dissembled in step 9.
17	Before applying pressure in the cuff, is the needle at zero?	Needle in the dial should be at zero when no pressure is applied.

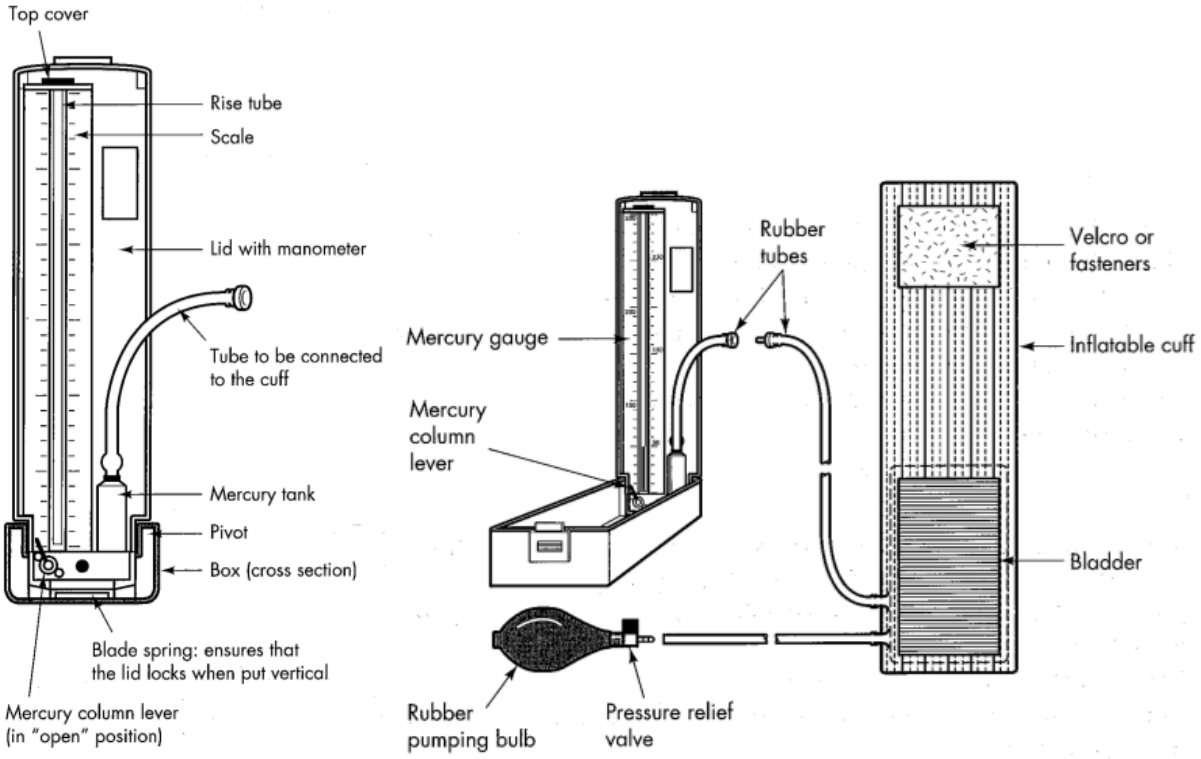
18	Open meter and manually twist the needle to zero.	Screw off dial cover and use a screwdriver to loosen or remove needle. Reassemble once needle is back at zero.
19	Can air be pumped into the cuff?	Try putting cuff around your arm or a bottle before pumping air. Is there difficultly in pushing air into the cuff? Does it deflate immediately?
20	Check the valve. Ensure that the knob is turned completely clockwise.	Valve must be turned completely clockwise to inflate the cuff.
21	Clean filter between the bulb, valve, and cuff connection.	Remove the valve from the bulb and cuff tubing. Use a screwdriver to scrape out any dirt in valve connection, or see BTA skills on Blockages Reassemble bulb, valve, and cuff tubing.
22	Check the bulb. Replace if necessary.	Is the bulb able to pump air? Are there any holes or leakage in the bulb? Repair with silicon if possible. Bulbs will typically need to be replaced. See BTA skills on Seals and Leaking.
23	Pump air to a particular pressure and hold for at least 10 seconds.	Pump air to a pressure of approximately 180 mmHg for a human arm.
24	Does the pressure drop significantly?	If the pressure drops more than 5 mmHg in 10 seconds, there is probably a leak.
25	Test for leaks in tubing and between connections.	Use BTA skills for cracks or leaks.
26	Release the air from cuff.	Turn knob completely counterclockwise.
27	Is air being released from the cuff?	You will hear air being released from the valve, and the cuff should deflate with no difficulty.
28	Check the valve. Ensure that the knob is turned completely counterclockwise.	Valve must be turned completely clockwise to deflate the cuff.
29	Clean filter between the bulb and cuff connection.	Remove the valve from the bulb and cuff tubing. Use a screwdriver to scrape out any dirt in valve connection, or see BTA skills on Blockages. Reassemble bulb, valve, and cuff tubing.
30	Test for accuracy and calibrate if necessary.	Use BTA skills on Calibration to calibrate sphygmometer.
31	BP cuff is working properly.	Return apparatus to appropriate clinical staff.

How To: Dissemble a Mercury Manometer

- Remove the cuff and tubing from the mercury apparatus
- Open the mercury column lever, and tilt the apparatus back to allow any mercury in the column to run into the reservoir
- Remove the tank cover (usually using a screwdriver)
- Remove all mercury from the tank using a syringe
- Pour mercury into a clearly labeled container, following proper protocol
- Remove cover over the rise tube (usually using a screwdriver)
- Take out the rise tube

How To: Clean Mercury

- Roll a sheet of paper into a funnel
- The pointed end should have a tiny hole
- Put the funnel in a bottle
- Pour the mercury into the funnel and let pass through



How To: Take Blood Pressure

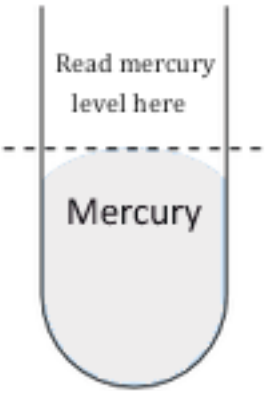
1. Prepare the patient.
    - Sitting down
    - Arm unobstructed
    - Ask about blood pressure history
2. Wrap the cuff around the upper arm with leads facing the brachial artery. Should be about level with the heart. Be sure that it is the proper cuff size for the patient's arm.
3. Put on stethoscope. Listen to the brachial artery very close to the cuff.
4. Ensure that the knob is turned completely clockwise.
5. Pump the cuff to a high pressure (for adults: 160-180 mmHg, for children: 140 mmHg)
6. Carefully turn the knob counterclockwise to release the pressure in the cuff at a slow rate.
7. Look at the pressure on the dial while listening to the heartbeat through the stethoscope.
8. Obtain and record the blood pressure.
    - Systolic: the pressure at which you start to hear the heart beat
    - Diastolic: the pressure at which you stop hearing the heart beat

<u>Examples of ranges for healthy blood pressures:</u>

Age	**BP (Systolic/ Diastolic)**
Child, <6 months	90-105/70
Child, 6 months to 7 years	105-117/70
Adult	120/80

How To: Mercury-Handling Protocol

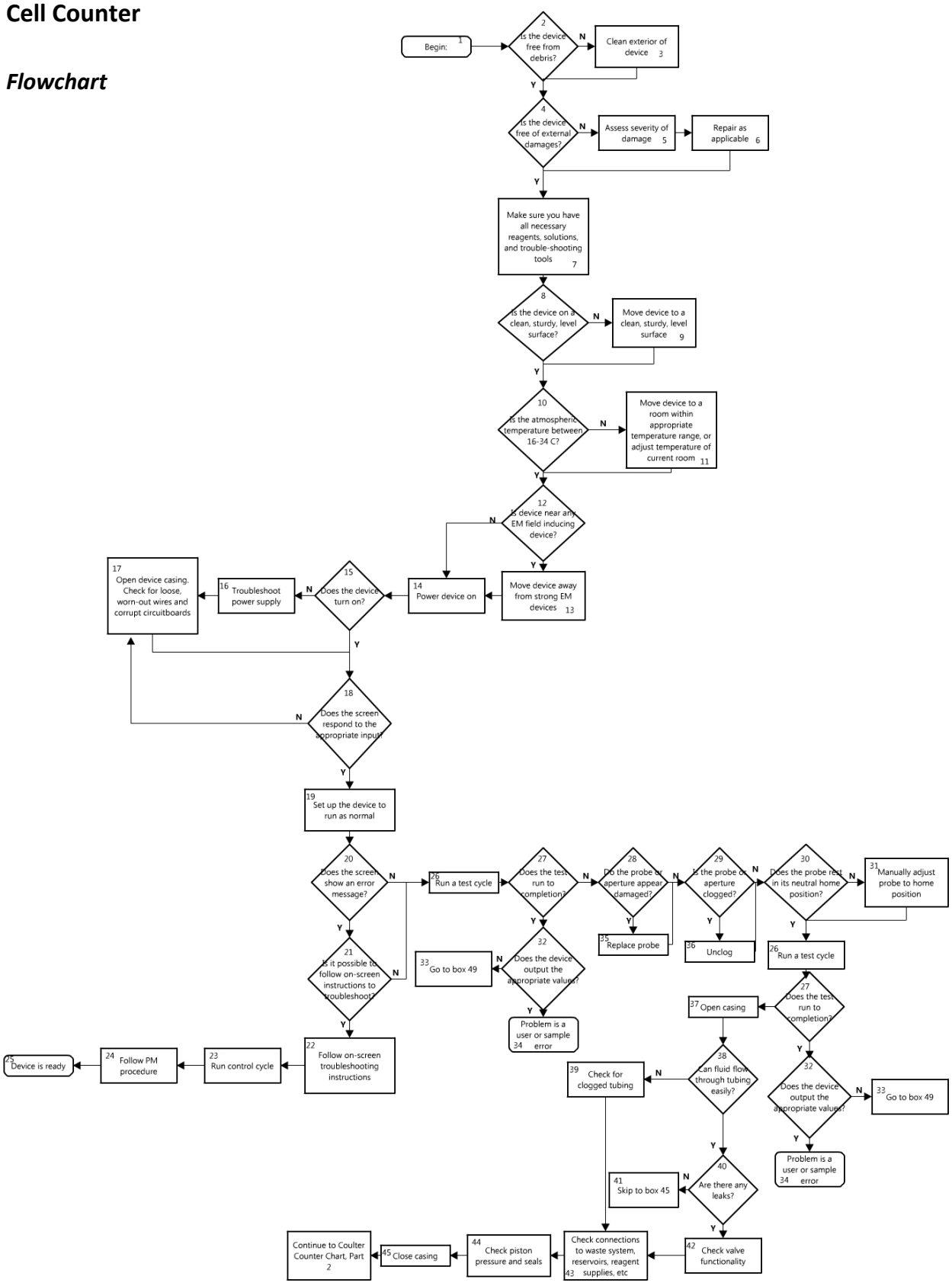
- When exposed to air, mercury vaporizes and is extremely poisonous
- Always handle mercury while wearing rubber gloves
- Work with mercury outside or in a well-ventilated area
- Recover mercury with a large syringe
- When storing mercury, add some water to prevent evaporation
- Always have an airtight cover on a mercury container
- Wash skin thoroughly if it comes into contact with mercury

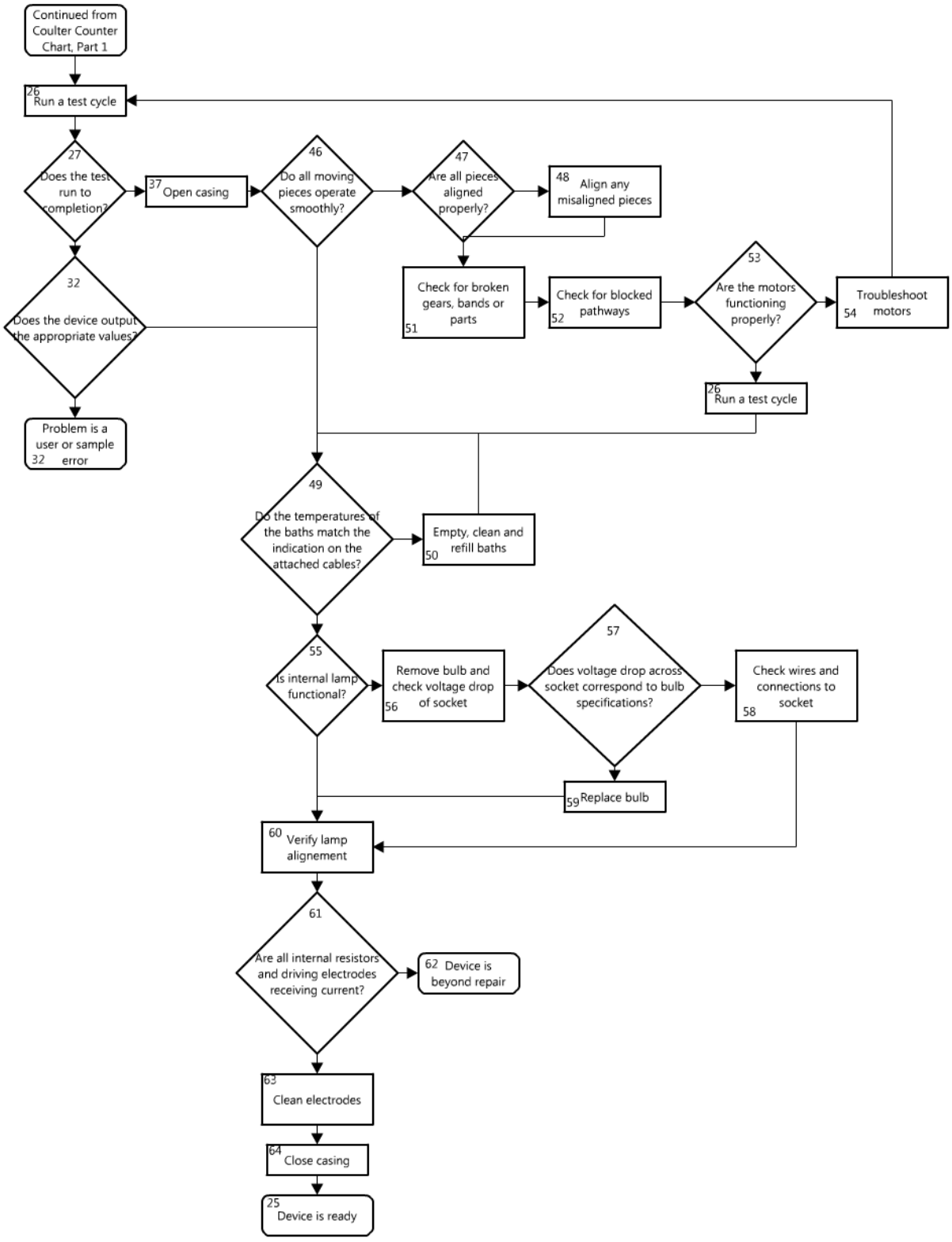


Thoughts/ Comments/ Ideas

Cell Counter

Flowchart




Continued from Coulter Counter Chart, Part 1
26 Run a test cycle
27 Does the test run to completion?
37 Open casing
46 Do all moving pieces operate smoothly?
47 Are all pieces aligned properly?
48 Align any misaligned pieces
32 Does the device output the appropriate values?
Problem is a user or sample error 32
Check for broken gears, bands or parts 51
Check for blocked pathways 52
53 Are the motors functioning properly?
Troubleshoot motors 54
26 Run a test cycle
49 Do the temperatures of the baths match the indication on the attached cables?
Empty, clean and refill baths 50
55 Is internal lamp functional?
Remove bulb and check voltage drop of socket 56
57 Does voltage drop across socket correspond to bulb specifications?
Check wires and connections to socket 58
59 Replace bulb
60 Verify lamp alignement
61 Are all internal resistors and driving electrodes receiving current?
62 Device is beyond repair
63 Clean electrodes
64 Close casing
25 Device is ready

Description

#	Text box	Explanation or comment
1	Begin	Start troubleshooting process for a work-order on a Cell or Coulter Counter.
2	Is the device free from debris?	Check exterior of device for any dirt, dust or other debris.
3	Clean exterior of device	Often parts appear broken or malfunctioning when they are simply not clean. It is most important to ensure that all openings, hinges and connecting or interacting pieces are clean. See BTA skills for Cleaning.
4	Is the device free of external damages?	Check for dents, scratches, and other major damage to the outside of the device. In particular, look to see if there is evidence of whether or not the device has been dropped.
5	Assess severity of damage	Damage to the exterior of the device can indicate the presence of internal damage and offer insight as to where inside the casing to begin looking for damage. If damage to the exterior is minimal it can likely be ignored. If too severe, it is possible the device will not function at all.
6	Repair as applicable	Using appropriate BTA skills on Casing, Attachment and Cleaning, repair scratches, dents, etc as possible.
7	Make sure you have all necessary reagents, solutions and trouble-shooting tools	It is a possible user error that the device is simply missing key components that are involved in its use but are not inherently present within the device. If possible, check the user manual or any other type of documentation, to determine whether or not the appropriate auxiliary components are being used, and being used properly.
8	Is the device on a clean, sturdy, level surface?	The measurements that this device makes are minute and precision is of the utmost importance. A sturdy and level surface is necessary to ensure accurate results.
9	Move device to a clean, sturdy, level surface	A clean, sturdy, level surface is one that does not wobble visibly or tangibly when the device is operated, is not on a slant, and is wiped free from dust and debris.
10	Is the atmospheric temperature between 16-34 C?	Use a thermometer to check. 16-34 C is the optimal operating temperature for both the electronic and liquid components of the device.
11	Move device to a room with appropriate temperature range, or adjust temperature of current room	Execute as possible.
12	Is device near any EM field inducing device?	EM (Electro Magnetic) fields are generated by very powerful devices such as x-ray machines, scanners, anything with a radar, etc. These fields can interfere with the circuitry and the accuracy of device measurements.
13	Move device away from strong EM devices	The simplest solution to this problem is to move the device, which, though bulky, is likely much more portable than any of the EM field generating devices.
14	Power device on	Press the “on” or “power” button or switch.
15	Does the device turn on?	Look for visible signs that the device has turned on. Indicators could be sounds of pieces within the device loading up and

		moving, a screen lighting up, an LED (typically green) illuminating, etc.
16	Troubleshoot power supply	Consult BTA skills on Power Supply and Power Supply flowchart for assistance.
17	Open device casing. Check for loose, worn-out wires and corrupt circuit boards.	Inspect the way that the casing is put together and use BTA skills for Casing to determine the order that the pieces need to be removed. Inspect for worn-out, frayed, rusted, etc wires. Use BTA skills Electrical Simple to repair as necessary.
18	Does the screen respond to the appropriate input?	Press the keypad or screen (if touchscreen) or appropriate buttons to prepare device as if to run a cycle. Determine whether or not the screen is responding as it should. Possible examples of incorrect screen inputs include moving to the incorrect menu (one that does not correspond to the input pressed), a frozen screen, an error message, etc.
19	Set up the device to run as normal	Set all system modes and settings as if a sample were to be run normally. This verifies that the device is being used properly and that, as troubleshooting continues, user error is not a factor.
20	Does the screen show an error message?	Error messages are fairly obvious as they are accompanied by the words “caution”, “error”, “warning”, etc. Error messages serve as an internal way for the device to give a better indication of which area of the device is malfunctioning.
21	Is it possible to follow on-screen instructions to troubleshoot?	With higher-level and more modern models, the device may have software designed to guide the troubleshooting process.
22	Follow on-screen troubleshooting instructions	If it is built into the software, the device will guide through the steps to take to approach problems associated with the malfunctioning part of the machine.
23	Run control cycle	Control cycles are run with deionized water. The system is set to run as it would normally with a sample, but only deionized water is used for the “sample” and each of the reagents. This enables the observation of all of the moving parts within the device and also shows whether or not the device is functioning mechanically, even if it does not display that proper results or values.
24	Follow PM procedure	See accompanied PM (Preventative Maintenance) procedure.
25	Device is ready	Device should be functioning properly
26	Run a test cycle	A test cycle is the same as a control cycle. See explanation for Box 23.
27	Does the test run to completion?	The test cycle has run to completion if the cycle drew the water through all of the appropriate channels, was not stopped along the way, produced no error messages, and displayed results at the end.
28	Does the probe or aperture appear damaged?	The sample probe is a thin metal rod with a small opening, like a needle, that is open to the exterior of the device. It is used to draw up the sample into the device to initiate a run cycle. A damaged probe is likely to be bent or chipped. The aperture is inside the device and is sized on the order of millimeters. A damaged aperture is likely to be cracked or corroded.
29	Is the probe or aperture clogged?	As the probe serves to draw fluid up and into the device and as the aperture facilitates fluid flow through the device, it is possible that debris may build up causing either to clog and thereby inhibit the analysis of the sample. See BTA Skills on Blockages.

30	Does the probe rest in its neutral home position?	The neutral home position of the probe should be marked, either by a tick mark or a line on the casing, or on the probe itself. If this mark exists, make sure that the probe is aligned properly so that it is functioning at maximum capacity. If the device does not have a marking to indicate the neutral home position, place an empty sample collection container in the appropriate position as if the device were to run a test, and verify that the probe is in a position so that it can draw up the entirety of the contents of the sample collection container.
31	Manually adjust probe to home position	It is possible that the probe may be adjusted or calibrated via instructions and a process through the device software on the screen. See BTA skills on Calibration. If this is the case, follow these instructions. Otherwise, it is likely that the probe is held in position by a series of set screws that can be manually adjusted.
32	Does the device output the appropriate values?	Look at the display screen to verify that the software of the machine is functioning. Specific values vary by model and brand; the main objective of this step is to make sure that the electronic components of the device are functional, if not necessarily accurate.
33	Go to box 49	
34	Problem is a user or sample error	Each of the components of the device are functioning properly.
35	Replace probe, if possible	If not possible, the device cannot function.
36	Unclog	Probe may be unclogged simply by soaking and washing with warm, deionized water. If necessary, it may also be unclogged using a small needle or brush, depending on the size of the probe and its opening. Aperture can be unclogged using a small needle or brush, but must be done gently so as not to damage the device. See BTA skills on Blockages.
37	Open casing	If it hasn't been done yet, open the casing as described in step 16. Opening the casing not only allows for inspection of the electronic elements, but also provides an opportunity to inspect the basic physical and mechanical workings of the device. See BTA skills on Casing.
38	Can fluid flow through tubing easily?	Indicators of fluid not flowing easily are bubbles, leaks or the machine stopping. See BTA skills on Blockages.
39	Check for clogged tubing	Tubing may be clogged simply by having folded in on itself, or having been pinched to prevent flow. It may also be clogged by debris or build-up. Any cause of clogging should be removed, if possible, by removing and rinsing the tubing or using a small brush if the clog is near the opening. If necessary, tubing can also be replaced. See BTA skills on Blockages.
40	Are there any leaks?	Leaks can stem from defective tubing, broken valves, broken reservoirs, or any of the connections between these parts. Clamps are also a suitable solution to this problem. See BTA skills on Leaking and Clamps.
41	Skip to box 45	
42	Check valve functionality	An alternative and more specific source of leaks may be the valves. Valves or valve parts that wear down (like O-rings) can wear down and lose their water-tight properties.
43	Check connections to waste system,	Leaks will often stem not from a particular part, but the places

	reservoirs, reagent supplies, etc	where parts intersect and interact. These can be replaced, tightened, or patched up accordingly. See BTA Skills on Connections and Seals.
44	Check piston pressure and seals	Not every model of the device will contain pistons, however many do, and the purpose of the pistons is to draw up and transport solution to different parts and processes within the device. It is imperative that the piston is actually drawing up liquid. If not, the seals can be adjusted and tightened. If the problem persists, the piston probably needs to be replaced. See BTA skills on Seals and Motors.
45	Close casing	When opening casing, be sure to keep track of all panels and screws. Close the casing in the exact reverse of opening the casing. See BTA skills on Casing.
46	Do all moving pieces operate smoothly?	As the control/test cycle runs, verify that pieces that are supposed to be moving, are doing so properly. The device can break down is via the wear and tear of basic mechanical components. Although it cannot be predicted which pieces exactly are of critical loading, visually inspecting the system as it runs can verify whether or not there is anything grinding, catching, in need of lubrication, broken, blocked, caught, etc. See BTA skills on Mechanical and Motors.
47	Are all pieces aligned properly?	It is possible, especially if there is any evidence of external damage or dents, the device is not functioning properly because the moving parts are misaligned.
48	Align any misaligned pieces	Most pieces or parts are held in place by set screws or hex screws that can be loosened to allow for the adjustment of the piece. As a general rule, all interacting parts with a round geometry should align concentrically and all translational parts should move in straight, perpendicular lines.
49	Do the temperatures of the baths match the indication on the attached cables?	For most models, the desired temperature range for the baths or reservoirs of each of the liquids or reagents used in a run cycle will be marked on the small cable connecting the hot plate (or similar mechanism) that maintains the temperature, to the power supply. Use a thermometer to verify that the temperature of the specific liquid falls within the appropriate range. However, if the temperature does not match properly, very few models have associated processes to fix the problem.
50	Empty, clean and refill baths	Reagents in device should be discarded appropriately. The device can be cleaned using deionized water only, and running a test or, if the model has one, a cleaning cycle. Baths can then be refilled. It is possible that temperature, and even general device running issues stem from build-up in the tubing, reservoirs and baths.
51	Check for broken gears, bands or parts	As the control cycle runs, visually check for any mechanical load bearing or linking parts that may have broken. Fix these as possible.
52	Check for blocked pathways	As parts move within the device, it is possible, especially if there is evidence of external damage, that pieces or parts within the device have shifted or been knocked out of place. In addition to throwing off alignment, this can manifest itself as the blockage of the pathway of a moving part. Any blockages should be cleared, and if any of the blockages involve broken or misplaced parts,

		these should be reattached or replaced as appropriate.
53	Are the motors functioning properly?	Although not the case for all models of the device, many power the movement and coordination of internal parts and pieces with motors. To ensure that the device is working properly, check to see if the motors are functioning properly. A properly functioning motor will make a small, continuous whirring sound when operating, and will lead to the motion of another piece or part within the device. See BTA skills on Motors.
54	Troubleshoot motors	Motors commonly fail in two ways: mechanically and electrically. Motors can wear out, or jam or their rotor may be blocked. Electrically, the wiring in and around the motor can be checked as well. See BTA skills on Motors and Electrical Simple.
55	Is internal lamp functional?	In addition to a resistance or voltage-based aperture measurement, many models, especially the more modern models, have a lamp or light device of some kind that is used in conjunction with photosensors to take various measurements from a sample. To check if the lamp is functional, first verify whether or not the lamp is “on” when the device is “on.” It may also be possible to use the software menus to turn the lamp on or off. A lamp is deemed functional if it emits light under the appropriate conditions.
56	Remove bulb and check voltage drop of socket	Use potentiometer to verify that the lamp component is receiving current. See BTA skills for Lighting/Indicators.
57	Does voltage drop across socket correspond to bulb specifications?	If the lamp has a bulb component, it is likely to have printed specifications as to the current and voltage that correspond to the optimal functionality of the bulb. Use a multimeter to check the voltage. See BTA skills for Lighting/Indicators.
58	Check wires and connections to socket	The simplest way that the lamp component may fail, other than a broken or worn out bulb, is in the immediate circuitry connecting the lamp to the power supply. See BTA skills for Lighting/Indicators.
59	Replace bulb	If the socket is receiving the appropriate current and voltage, the problem lies within the bulb, which should be replaced. See BTA skills for Lighting/Indicators.
60	Verify lamp alignment	More modern models typically have software menus to guide through the lamp alignment process. If not, the lamp can be more roughly aligned by verifying that the accompanying photosensors are responding appropriately. As with many of the moving parts of the device, the lamp can be adjusted manually after loosening the appropriate set screws.
61	Are all internal resistors and driving electrodes receiving current?	Use a multimeter to check that there is a voltage drop across and current is running through the key electric components.
62	Device is beyond repair	
63	Clean electrodes	Electrodes can be cleaned with deionized water. See BTA skills on Switches and Connectors.
64	Close casing	When opening casing, be sure to keep track of all panels and screws. Close the casing in the exact reverse of opening the casing. See BTA skills on Casing.
65	Device is ready	

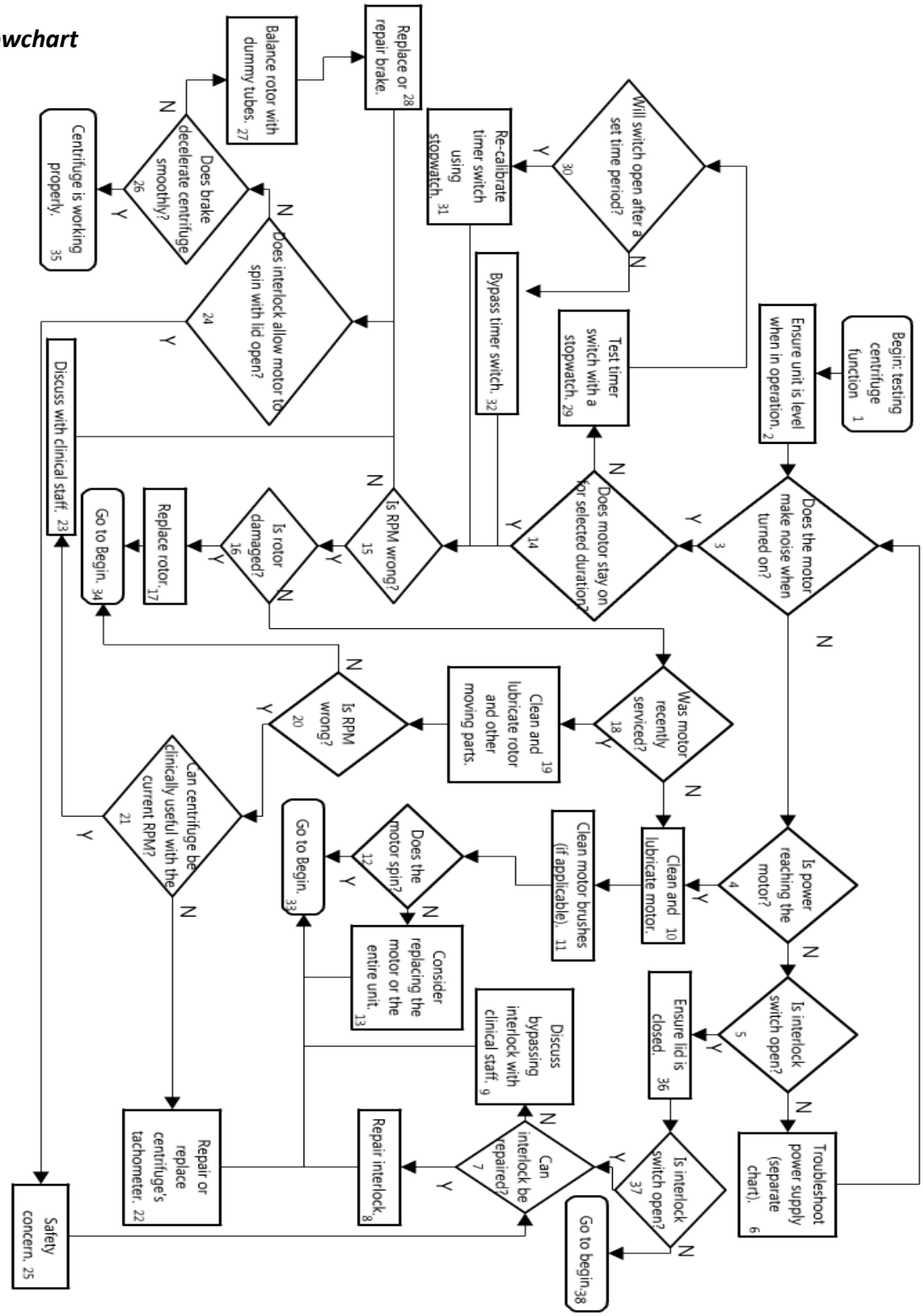
Preventive Maintenance

- Clean casing
- Check to make sure all proper reagents and auxiliary equipment are being used
- Inspect power cords and plugs
- Check menu and software settings
- Check for clogged probe
- Run a test cycle using deionized water

Thoughts/ Comments/ Ideas

Centrifuges

Flowchart



Description

#	Text box	Explanation or Comment
1	Begin: testing centrifuge function	Start the diagnostic process for a work order on a centrifuge.
2	Ensure unit is level when in operation.	Operating an unbalanced centrifuge can cause inaccurate speeds, damage to the machine, or damage to operators. To ensure levelness, each tube being spun should have a counter-balance tube placed in the position directly across from it. If the number of samples being spun is uneven, a tube filled with an equivalent volume of water will suffice to balance.
3	Does the motor make noise when turned on?	If the centrifuge is working properly, the motor will spin and create noise.
4	Is power reaching the motor?	Use a multimeter to test the wires leading to the motor to determine if it is receiving the expected voltage.
5	Is interlock switch open?	The interlock switch prevents the motor from operating with the lid open. If the switch is open, power is disconnected from the motor.
6	Troubleshoot power supply (separate chart).	If interlock switch is closed and no power reaches the motor, there is a problem with the power supply. This could be an issue with the wiring or fuse for AC motors. See Power Supply flowchart, and BTA skills on Power Supply and Electrical Simple.
7	Can interlock be repaired?	The lid is closed and the interlock switch is open, so the interlock must be repaired. Search for a mechanical solution to trip the switch when the lid closes. See BTA skills on Attachment and Casing.
8	Repair interlock.	A mechanical adjustment could be made to trigger the switch, or possibly the switch could be replaced. See BTA skills on Attachment and Casing.
9	Discuss bypassing interlock with clinical staff.	If the interlock switch can't be repaired, it can be bypassed by hard-wiring the two wires together. This will eliminate the safety feature and allow the rotor to spin with the lid open. Discuss the safety implications with the clinical staff to determine if this solution is acceptable, and see BTA skills on Connections, Connectors and Switches.
10	Clean and lubricate motor.	See BTA skills on Cleaning / Lubrication of Motors.
11	Clean motor brushes (if applicable).	See BTA skills on Motor Brushes.
12	Does the motor spin?	Test if corrective measures have allowed motor to spin.
13	Consider replacing the motor or the entire unit.	The motor is powered and cannot spin after corrective measures. Replace motor or entire unit.
14	Does the motor stay on for selected duration?	Select a duration using the timer switch and verify the accuracy with a stopwatch.
15	Is RPM wrong?	Measure RPM using paper tachometer and fluorescent bulb technique.
16	Is rotor damaged?	Check rotor for cracks, imbalances, and irregularities in the rotor.

17	Replace rotor.	If the rotor is damaged beyond repair, it must be replaced. It is unsafe to operate a centrifuge with a damaged or imbalanced rotor.
18	Was motor recently serviced?	The RPM is wrong. Has the motor been serviced recently?
19	Clean and lubricate rotor and other moving parts.	See BTA skills on Bearings and Motors.
20	Is RPM wrong?	Measure RPM using paper tachometer and fluorescent bulb technique.
21	Can centrifuge be clinically useful with the current RPM?	The correct RPM cannot be attained.
22	Repair or replace centrifuge's tachometer.	The tachometer determines the RPM. A faulty tachometer can cause an incorrect RPM.
23	Discuss with clinical staff.	Consult with clinical staff to see if current RPM is still useful.
24	Does interlock allow motor to spin with lid open?	Check if motor can spin with an open lid.
25	Safety concern.	If the motor is allowed to operate with the lid open, there is a concern that someone could be injured by the rapidly spinning rotor.
26	Does brake decelerate centrifuge smoothly?	Check if the rotor decelerates smoothly while the brake button or lever is held.
27	Balance rotor with dummy tubes.	The rotor needs to be loaded such that each tube is countered by one on the opposite side to ensure balance.
28	Replace or repair brake.	The brake might be mechanical or a resistor that is placed across the motor.
29	Test timer switch with a stopwatch.	Compare the time period set by the switch to the actual duration using a stopwatch.
30	Will switch open after a set time period?	Will the timer switch open and stop the motor after any amount of time, even if the time isn't correct?
31	Re-calibrate timer switch using stopwatch.	If the timer switch stops the motor, but not at the right time, the timer switch can be calibrated. Re-label the timer switch to indicate the actual time durations that were measured. See BTA skills on Calibration.
32	Bypass timer switch.	If the timer switch will never stop the motor, consider bypassing this switch or replacing it with a simple “on-off” switch. The clinician will have to turn the machine on and off manually. Perhaps another watch or timer can be used to time the centrifuge manually. See BTA skills on Electrical Simple,
33	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
34	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
35	Centrifuge is working properly.	Return the machine to service via the appropriate clinical personnel.
36	Ensure lid is closed.	The lid must be closed to open the interlock switch.

37	Is interlock switch open?	The interlock switch prevents the motor from operating with the lid open. If the switch is open, power is disconnected from the motor.
38	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.

Preventive Maintenance

- Lubricate and clean motor.
- Clean case.
- Inspect power cords and plugs.
- Inspect controls and switches.
- Ensure appropriate menu settings for proper use.
- Ensure tightness of rotor.
- Check lights and indicators.
- Verify that alarms are operating properly.
- Ensure interlock is functioning.
- If refrigerated, ensure temperature reading is working.Replace/repair gaskets, seals, and vacuum pump (if applicable).

NOTES:

Check holders for rubber stoppers that cushion tubes. All holders should have then or the centrifuge will be unbalanced and will wear the brushes and rotor.

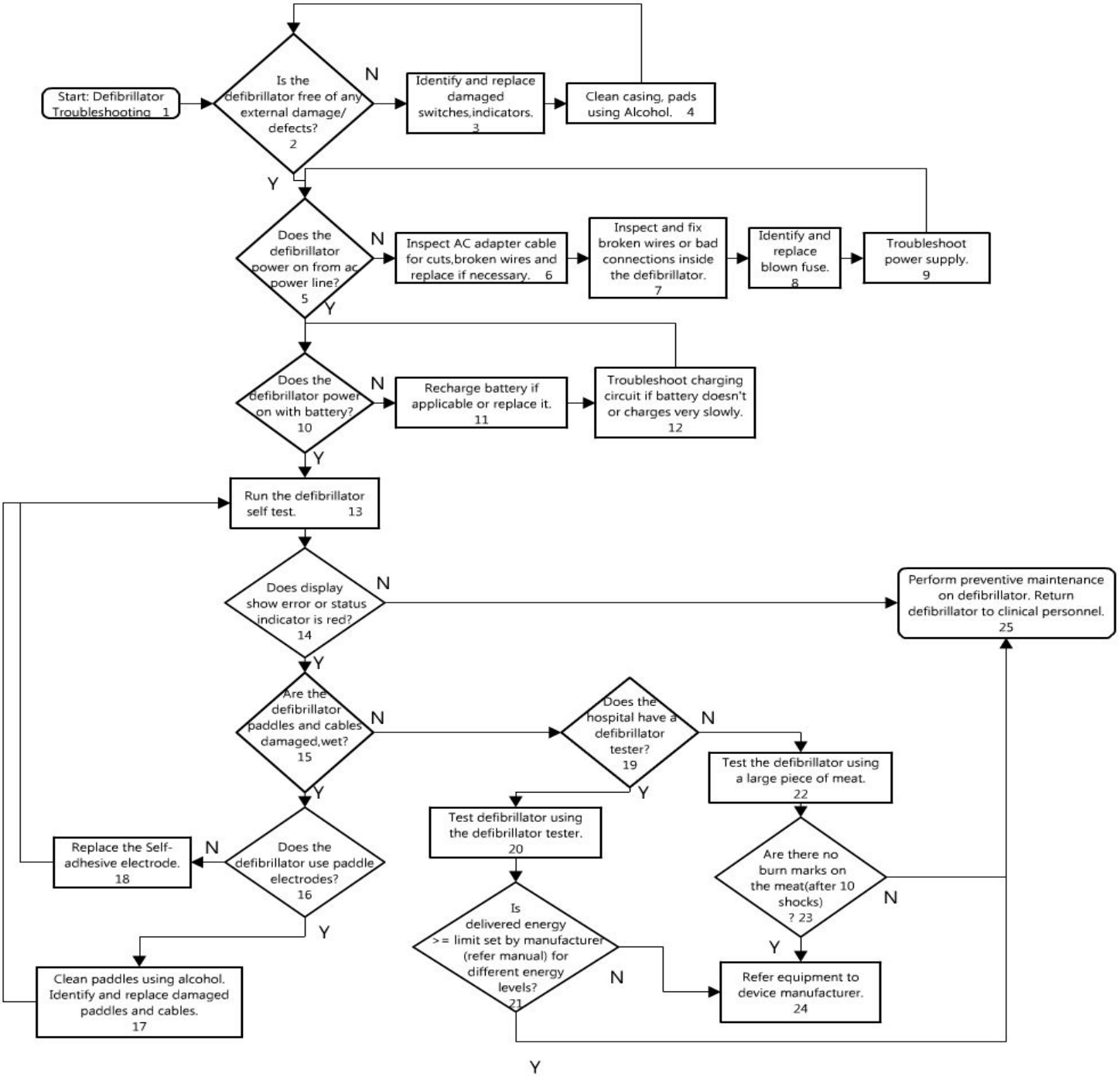
Check carbon brushes and replace with same size.

Cleaning should be step one. It is important to disinfect/decontaminant before doing any other maintenance or repair. Often centrifuges have had broken tubes of blood or urine so will be a source of contamination.

Thoughts/Comments/Ideas

Defibrillator

Flowchart



Description

	Text Box	Comments
1	Start: Defibrillator Troubleshooting.	Begin diagnostic process for a work order on Defibrillator
2	Is the defibrillator free of any external damage/defects?	Inspect defibrillator for external cracks, broken switch, knobs and indicators.
3	Identify and replace damaged switches, indicators.	See BTA skill set on Switches and Lighting/Indicators to identify and replace damaged switches and indicators.
4	Clean casing, pads using Alcohol.	Examine casing, pads and cables of defibrillator for gel and dirt. Refer BTA skill set on Cleaning to clean the defibrillator. If necessary, address damage to casing with BTA skills on Casing.
5	Does the defibrillator power on from ac power line?	Power the device from ac line and turn it on.
6	Inspect AC adapter cable for cuts, broken wires and replace if necessary.	See BTA skill set on Connections and Connectors for identifying and replacing damaged cables.
7	Inspect and fix broken wires or bad connections inside the defibrillator.	Inspect wires and connections from power supply circuit board to other boards using multimeter. See BTA skill set on Connections for identifying and fixing broken wires and bad connections.
8	Identify and replace blown fuse.	See BTA skill set on Fuse to identify and replace blown fuse.
9	Troubleshoot power supply.	Most defibrillators can power on from battery and ac power mains. See flowchart on Power Supply, and BTA skills on Power Supply.
10	Does the defibrillator power on with battery?	Disconnect defibrillator from ac power line. Turn the device on. • If battery/status indicator is red then battery needs to be charged or replaced (non-rechargeable). • If defibrillator fails to power on then battery is fully depleted or damaged.
11	Recharge battery if applicable or replace it.	See BTA skill set on Batteries to replace and identify damaged batteries.
12	Troubleshoot charging circuit if battery doesn't or charges very slowly.	See BTA skill set on Transformer and Regulators to troubleshoot charging circuit.
13	Run the defibrillator self-test.	Power the device from ac line and turn it on. The device will run an automatic self-test.
14	Does display show error or status indicator is red?	The result of the self-test will be displayed (on the screen) or status indicator will change red/green.
15	Are the defibrillator paddles and cables damaged, wet?	The paddles should be clean and dry. Inspect the pad cables and connectors for cuts and broken wires.
16	Does the defibrillator use paddle electrodes?	Paddle electrodes consist of a metal paddle with an insulated handle.
17	Clean paddles using alcohol. Identify and replace damaged paddles and cables.	Paddle electrodes are reusable and should be cleaned after every use. See BTA skill set on Connections and Connectors for identifying and replacing damaged cables.

18	Replace the Self-adhesive electrode.	Self-adhesive electrodes should be replaced after every use.
19	Does the hospital have a defibrillator tester?	Defibrillator testing can be done on a commercial tester or a large piece of meat.
20	Test defibrillator using the defibrillator tester.	Connect pads to defibrillator analyzer. Select energy and press charge button. Once charged push discharge button. Record delivered energy from display of defibrillator analyzer. Repeat the procedure for different energy levels.
21	Is delivered energy >= limit set by manufacturer (refer manual) for different energy levels?	Improper functioning of internal circuitry if the defibrillator delivers less or no energy than the limit set by manufacturer.
22	Test the defibrillator using a large piece of meat.	Set energy to maximum and press charge button. Once charged place pads on a large piece of meat. Press discharge button. Repeat the procedure 10 times. The piece of meat should be large enough so that the defibrillator paddles can be placed greater than 6 inches apart.
23	Are there no burn marks on the meat (after 10 shocks)?	Failure of internal circuitry if no burn marks are found on the piece of meat.
24	Refer equipment to device manufacturer.	Refer equipment to device manufacturer for possible repair and replacement of internal circuitry components.
25	Perform preventive maintenance on defibrillator. Return defibrillator to clinical personnel.	Defibrillator is working properly. Perform preventive maintenance before returning the device to clinical personnel.

Preventative Maintenance

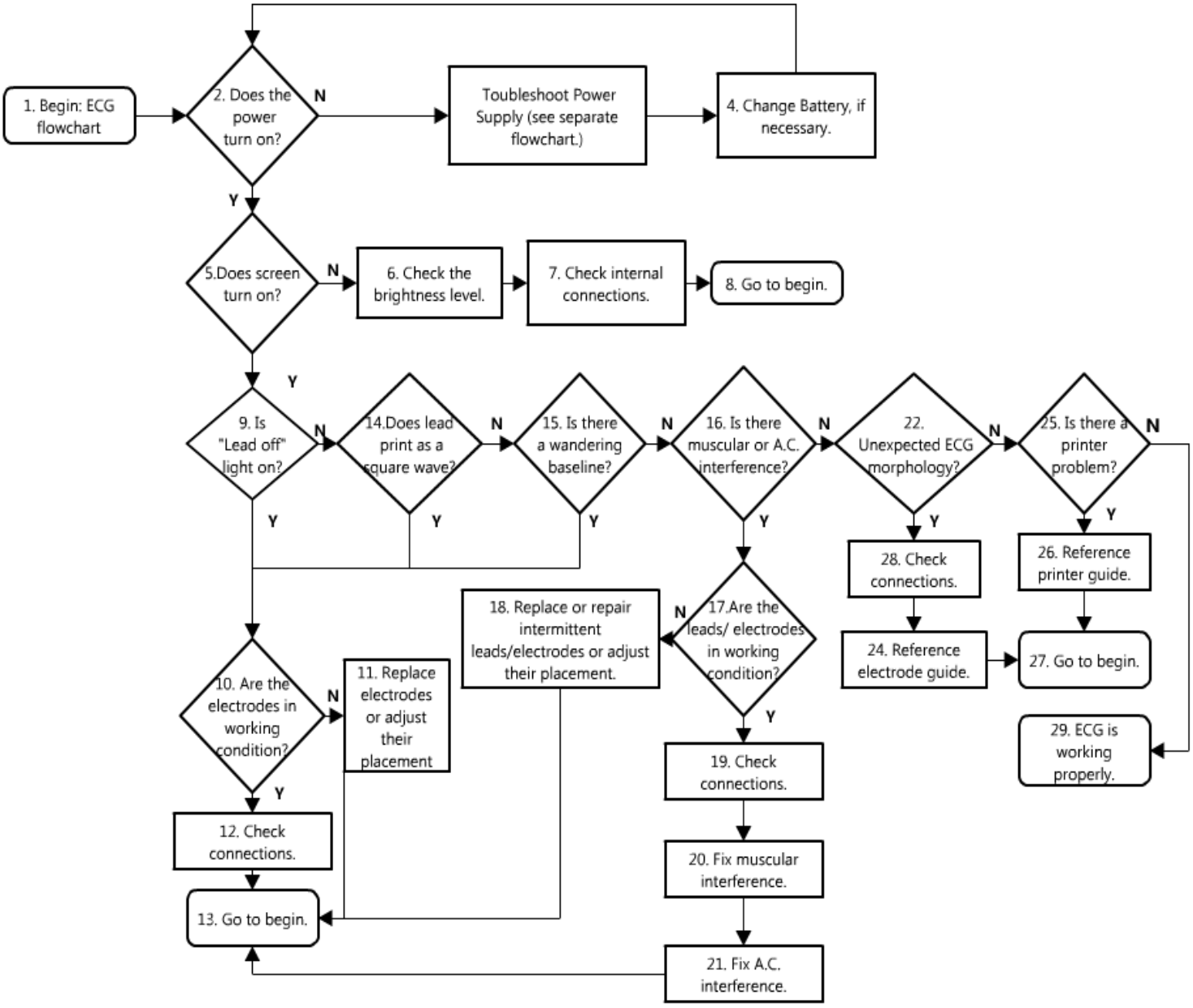
Common Reasons for Failure:

- Damaged device
- Damaged pads or cables
- Improper power supply
- Improper functioning of internal circuitry

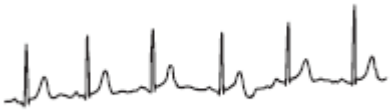
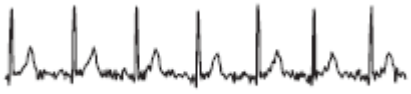
Thoughts/ Comments/ Ideas

Electrocardiogram (ECG)

Flowchart



Description

#	Text Box	Comments
1	Begin: ECG flowchart	Start diagnostic process for a work order on an ECG
2	Does ECG power on?	Lights, displays, and sounds are indications that device is powered on. Also, check the power cords for continuity. See BTA skills on Connections.
3	Troubleshoot power supply (separate flowchart)	ECG's have an AC to DC power supply. See Flowchart on Power Supply, and BTA skills on Power Supply.
4	Change battery if necessary.	If there is a battery, test its ability to receive and hold a charge. See BTA skills on Batteries.
5	Does screen turn on?	No obvious brightness or color change on display screen?
6	Check brightness level.	If possible, raise brightness level of screen.
7	Check internal connections.	Check for obvious wiring issues such as damaged or disconnected wires. See BTA skills for Connections and Electrical Simple.
8	Go to begin.	Return to box 1, Begin: ECG
9	Is "Lead off" light on?	"Lead off" light will likely be near display window. It indicates that there is a bad connection somewhere between the patient electrodes and the machine. (1) See BTA skills for Electrical Simple.
10	Are the electrodes in working condition?	Check for damage or corrosion to the electrode or electrode insulation.
11	Replace electrodes or adjust their placement.	See electrode guide below for replacement of electrodes as well as electrode placement and a conducting gel recipe. If possible, attach a patient simulator to the patient cables. If proper signal with simulator, electrodes are non-functional.
12	Check connections.	If possible, attach patient simulator to patient cables, if no signal replace cables. Ensure proper connections between ECG and electrodes and ensure patient is not moving. Make sure electrode has proper contact with patient's skin. (1) See BTA skills for Electrical Simple.
13	Go to Begin.	Return to box 1, Begin: ECG
14	Does lead print as square wave?	Does one or more lead display as a square wave?  (1)
15	Is there a wandering baseline?	Does display show an unsteady baseline signal?  (1) Note: In an analog ECG machine, a wandering baseline may be caused by the INSTO adjust or if the stylus pegs violently
16	Is there muscular interference or AC interference?	Does display show muscular or AC interference (picture): Even peaked, regular voltage superimposed on waveforms?  (1)
17	Are leads/electrodes in working condition?	Check for damage or corrosion to the electrode or electrode insulation. If possible, attach a patient simulator to the patient cables. If proper signal with simulator, electrodes are non-functional.
18	Replace or repair intermittent	See electrode guide below for replacement of electrodes as well as

	leads/electrodes or adjust their placement.	electrode placement and a conducting gel recipe.
19	Check connections.	If possible, attach patient simulator to patient cables, if no signal replace cables. Ensure proper connections between ECG and electrodes and ensure patient is not moving. Make sure electrode has proper contact with patient's skin. (1) See BTA skills for Electrical Simple.
20	Fix muscular interference.	Make sure patient is comfortable and not tense, if possible turn on muscular filter. See user's manual for instructions on muscular filter. (1)
21	Fix AC interference.	Verify that patient is not touching any metal. Verify power cable is not touching patient cable. If possible, turn on AC filter according to instructions in user's manual. Also, try running on battery power, if possible. (1) See BTA skills on Power Supply and Electrical Simple.
22	Unexpected ECG morphology?	Does display show an unexpected ECG morphology?
23	Reference electrode guide.	Check electrode guide below, particularly on lead placement to ensure proper location.
24	Check connections.	If possible, attach patient simulator to patient cables, if no signal replace cables. Ensure proper connections between ECG and electrodes and ensure patient is not moving. Make sure electrode has proper contact with patient's skin. (1) See BTA skills for Electrical Simple.
25	Is there a printer problem?	Does printer not print or print output that does not match display
26	Refer to printer guide	Use Printer flowchart to determine possible problems with printer output. ? If it is an analog ECG machine, the stylus heat and pressure can cause poor trace display. Refer to the service manual or online documentation.
27	Go to Begin	Return to box 1, Begin: ECG
28	Check connections	If possible, attach patient simulator to patient cables, if no signal replace cables. Ensure proper connections between ECG and electrodes and ensure patient is not moving. Make sure electrode has proper contact with patient's skin. (1) See BTA skills for Electrical Simple.
29	ECG is working properly.	Return the machine to service via the appropriate clinical personnel.

Preventative Maintenance

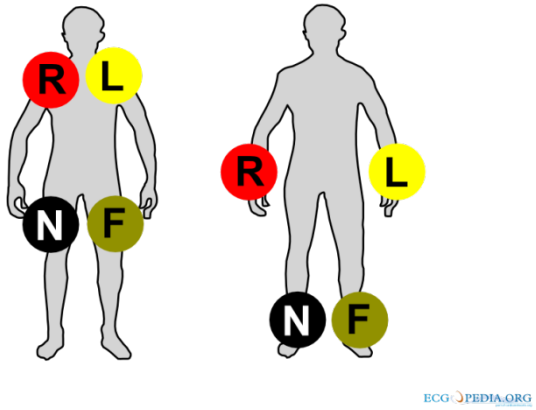
- Clean casing
- Clean electrodes and inspect for corrosion or adhered debris after each use
- Inspect insulation for defects and debris
- Inspect cables for defects, replace if necessary
- If battery-powered, regularly check batteries to prevent corrosion
- Re-stock and refill ink and paper as needed

Electrode Guide

Proper Placement of 12 Lead ECG

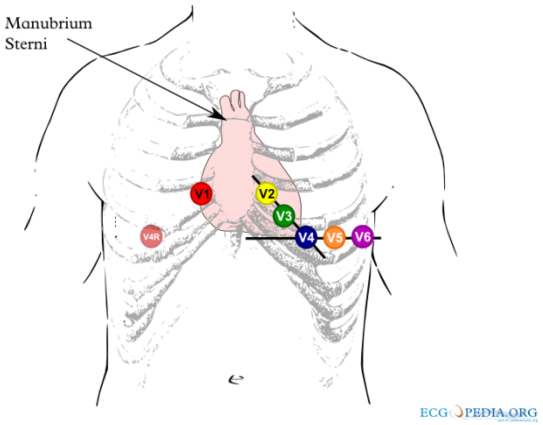
For the 4 extremity electrodes placement:

- L or LA is placed on the left arm
- R or RA is placed on the right arm
- N - neutral, on the right leg (= electrical earth, or point zero, to which the electrical current is measured)
- F - foot, on the left leg
- It does not matter whether the electrodes are placed on the bottoms or tops of extremities, but be consistent. Place electrodes in similar spots on extremities. (eg. do not attach an electrode on the left shoulder and one on the right wrist). Also, avoid bony parts such as elbows or knees.



For the 6 chest electrodes placement:

- V1 is placed to the right of the sternum in the 4th intercostal space.
- V2 is placed to the left of the sternum in the 4th intercostal space
- V3 is placed between V2 and V4
- V4 is placed in the 5th intercostal space on the nipple line. Place V4 beneath the breast in women.
- V5 is placed between V4 and V6
- V6 is placed in the midaxillary line on the same height as V4 on the horizontal line from V4 (not necessarily in the 5th intercostal space)



Common lead misplacements:

- Right and left arm electrode reversal
- Right leg and right arm electrode reversal
- Left arm and left leg electrode reversal
- Right arm and left leg electrode reversal
- Left arm and right leg electrode reversal

To make replacement ECG pads:

Materials

1. Bottle caps
2. Nickel-plated brass sewing snap buttons, size 3
3. Flathead screwdriver
4. Utility knife (boxcutter, X-Acto or another sharp-bladed, small knife)
5. Pot, water and a stove
6. Optional: tweezers/forceps

Steps

1. Boil the bottle caps in water for 30 minutes.
2. Peel off the lining. Start the peel by prying an edge off with the screwdriver, then carefully pull the rest out with your fingers or with tweezers or forceps. Take care not to rip the lining during this process. If the lining is too hard to remove, heat the cap in the water again.
3. Make an "X" in the center of the lining, about 1cm big.
4. Insert a size-3 nickel-plated brass sewing snap into it.
5. Trim the tiny corners of plastic from the edge of the button nub.

To make ECG conductive gel:

Materials

1. Water, one cup
2. Salt, two tablespoons
3. Flour, one cup
4. Bleach

Steps

1. Mix the water and salt.
2. Slowly pour in the flour. The mixture will become gelatinous. Mix it until it the consistency is the same.
3. Add a drop of bleach (to make the gel sterile).

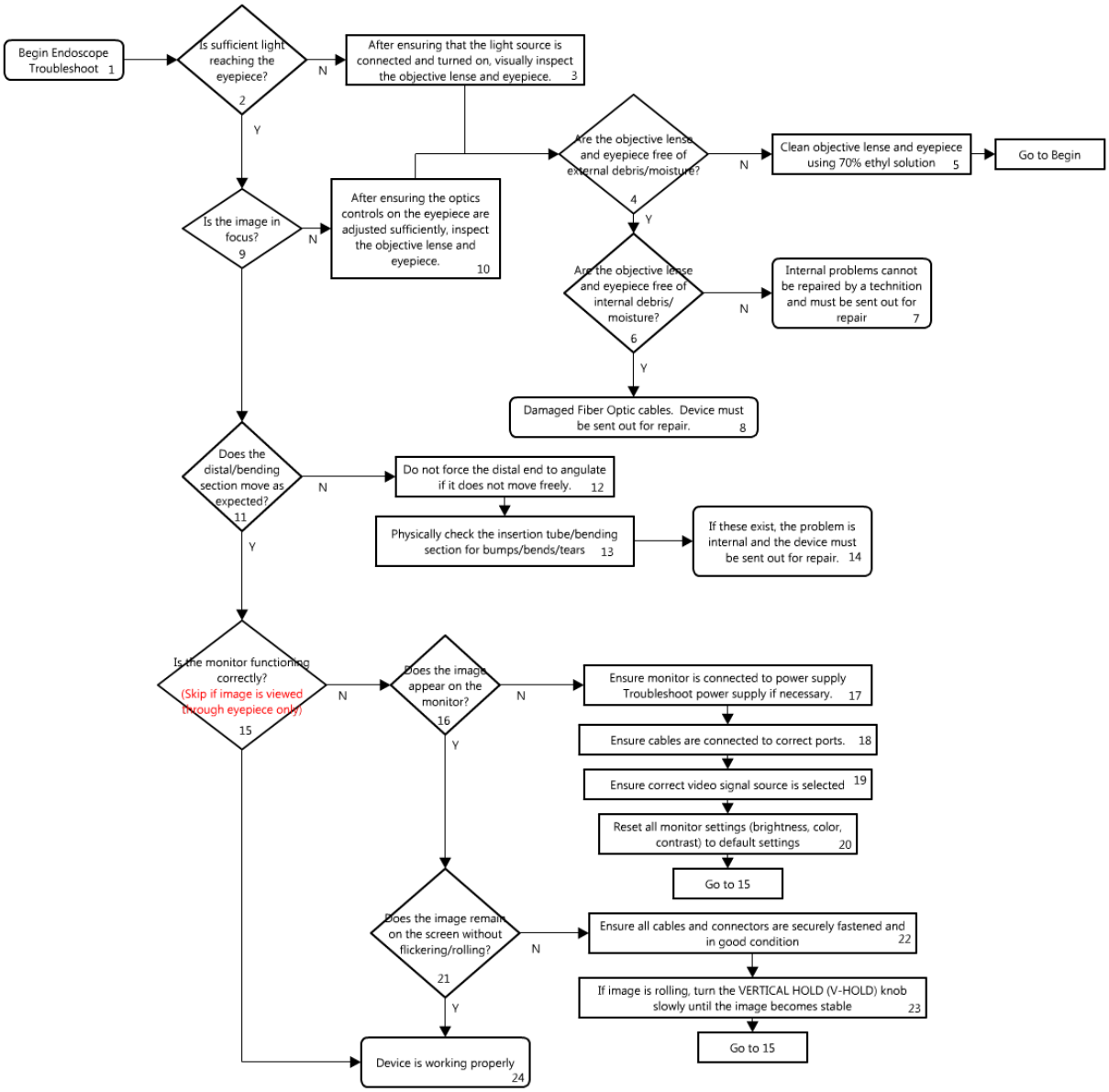
Proper skin preparation:

1. Shave body hair before application, if in excess.
2. Avoid placing electrodes on any burn or scar tissue.
3. Make sure electrodes have some sort of conductive gel between skin and metal contact.
4. Make sure electrode is firmly attached to skin. Apply tape, if necessary.
5. If steps 1-4 struggle, use a light skin abrasive such as sand paper.
6. Reapply conducting gel every couple of hours to avoid skin irritation and loss of signal.

Thoughts/ Comments/ Ideas

Endoscope

Flowchart



Description

#	Textbox	Explanation
1	Begin endoscope troubleshoot	Start the diagnostic process for a work order on the endoscope.
2	Is sufficient light reaching the eyepieces?	After turning on and connecting the light source to the light guide cable, hold the tip of the scope up to another bright external light. Does an equally bright image appear through the eyepiece? There should be few to no black spots (broken fiber optic wires). More than 10% of the image being black is considered unacceptable.
3	After ensuring that the light source is connected and turned on, visually inspect the objective lens and eyepiece.	Double check to make sure the light source is powered on, its power source is working, and all connections from light source to endoscope are tight and fitted properly. Then inspect both the eyepiece and the objective lens on the distal tip. Both should be free of dust/dirt/buildup. Check lens for cracks or scratches. See BTA skills on Electrical Simple – Connections.
4	Are the objective les/eyepiece free from external debris/moisture?	Is there a buildup of anything on the external surface of either the objective lens/eyepiece? This could include dust, dirt, fluid, scratches, cracks, etc.
5	Clean objective lens/eyepiece with 70% ethyl solution.	Wipe the external surface with a clean, lint-free cloth moistened with 70% ethyl or isopropyl alcohol. Never use an abrasive cleanser which might scratch the lens surface. If scratches are present, eyepiece/lens may need to be replaced. See BTA skills on Cleaning.
6	Are the objective lens/eyepiece free from internal debris/moisture?	After cleaning the outside of the lens/eyepiece, if the image still appears dark, visually inspect for internal buildup or moisture. Moisture would make the image appear foggy/unfocused.
7	Internal problems cannot be repaired by a technician and must be sent out for repair.	It is not possible to disassemble the endoscope to repair internal damage and water leaks. The equipment should be sent out for repair or replaced.
8	Damaged fiber optic cables. Device must be sent out for repair.	If dark, black spots appear in the image, some of the fiber optic cables are broken. If more than 10% of the image appears black, consider replacing the fiber optic cable. Do not attempt to disassemble and fix. Device must be sent out.
9	Is the image in focus?	Does the objective appear through the eyepiece clearly? The image should not appear “fuzzy” or unfocused. Sufficient focus is important for many procedures.
10	After ensuring the optics control on the eyepiece is adjusted sufficiently, inspect the objective lens and eyepiece.	Adjust the controls on/near the eyepiece on the endoscope control body. Turn the knob to bring the image in and out of focus until it is clear. If no optic control setting fixes the clarity, inspect the lens and eyepiece for obstruction.
11	Does the distal/bending section move as expected?	Test the response of the control knobs on the endoscope control body. The UP/DN knob should move the distal tip up and down, and the R/L knob should turn the tip from side to side. Check to make sure the knobs turn with ease and are not loose or cracked. See BTA skills on Mechanical – Attachment.
12	Do not force the distal end to angulate if it does not move freely.	If the tip does not angulate, DO NOT TRY TO FORCE IT. Angulation problems are usually a result of water damage or physical strain on the internal wires.
13	Physically inspect the insertion tube/bending section for bumps/bends/tears.	Run hand down the length of insertion tube from its connection to the control body down to the distal tip and objective lens. Physically feel and visually look for any holes, tears, wrinkles, buckles, bends, etc.
14	If these exist, the problem is	If any external damage exists on the insertion tube, it should be

	internal and the device must be sent out for repair.	replaced. Do not attempt to repair the insertion tube with epoxy/sealant, as this could damage the device further or put the patient at serious risk.
15	Is the monitor functioning correctly? (Skip this step if image is viewed through eyepiece only).	If the endoscope is connected to a monitor for viewing: Check display on monitor. The image should appear as it does through the eyepiece.
16	Does the image appear on the monitor?	Does the monitor display an image?
17	Ensure the monitor is connected to the power supply. Troubleshoot power supply if necessary.	Make sure the monitor is powered on, connected to a power source. See flowchart for Power Supply and BTA skills on Power Supply.
18	Ensure cables are connected to correct ports.	Check that the "video out" cable from the endoscope is connected to the "video in" port on the monitor. Make sure the connection is tight, and that the wire is undamaged. See BTA skills on Electrical Simple.
19	Ensure correct video signal source is selected.	Check monitor settings for the input source. If "NO SIGNAL" appears on the monitor, cycle through input sources until an image appears.
20	Reset all monitor settings (brightness, color, contrast) to default settings.	Default all monitor display settings.
21	Does the image remain on the screen without flickering/rolling?	Once an image appears, does it remain on the screen? The display should not bounce, flicker, or roll across the monitor.
22	Ensure all cables and connectors are securely connected, and in good condition.	Tighten all connections on endoscope and monitor. Make sure there are no tears in the wires. See BTA skills on Electrical Simple.
23	If image is rolling, turn the VERTICAL HOLD (V-HOLD) knob slowly until the image becomes stable.	If there are lines rolling across the monitor or the display is unsteady, locate the Vertical Hold knob/button on the back of the monitor. Adjust this setting slowly until the image no longer jumps.
24	Device is working properly.	The endoscope is in good working condition.

Preventive Maintenance

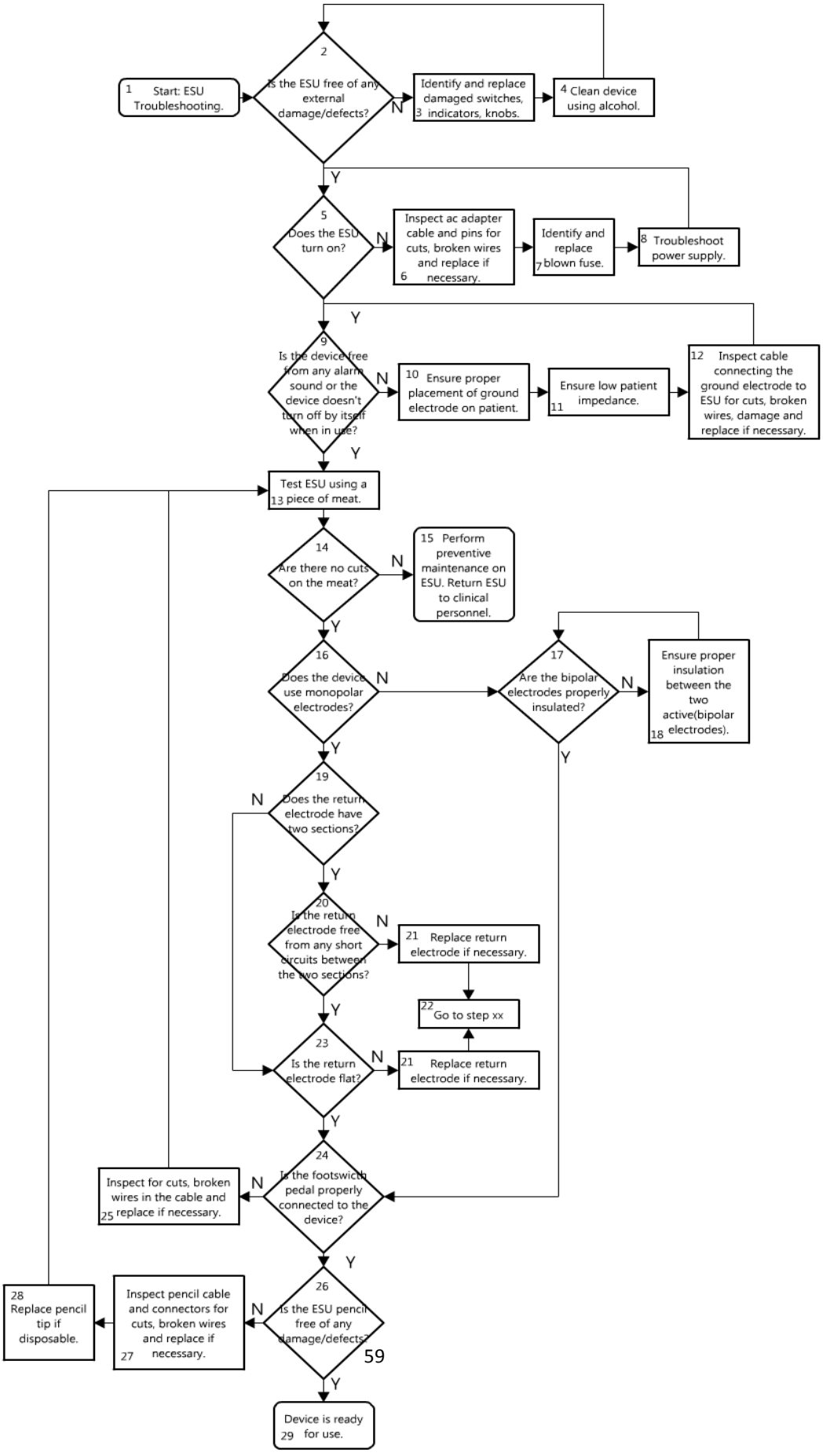
- Ensure the scope is stored in a dry, safe place where it is free from damage and environmental contamination. It is preferable for the scope to hang vertically, to facilitate drying and prevent moisture buildup
- Before and after each use of the endoscope it is important to ***inspect the equipment*** to prevent small problems from becoming larger
- MAKE SURE
    - No parts are missing or loose
    - The scope is free of damage (run your hand down the length of the insertion tube-down to the distal end to feel for dents, cracks or bends)
        - If damage is present: **THE DEVICE SHOULD BE SENT OUT FOR REPAIR IMMEDIATELY**. While the device may seem functional and able to be used, small cuts and tears can lead to major fluid invasion, which will cause a much larger/more expensive problem.
    - The scope is free of dirt or debris anywhere on its exterior

        - If dirt is present: thoroughly rinse with water. Remove persistent debris with a non-acidic cleaning agent. Rinse again with water. Use a non-abrasive, soft, lint-free cloth to dry equipment.
    - All optical surfaces (eyepiece cover lens, objective lens, video adapter lenses) are free of dirt/moisture
        - If dirt is present: clean with 70% ethanol using a non-abrasive, lint-free cloth

Thoughts/ Comments/ Ideas

ESU

Flowchart



Description

#	Textbox	Explanation
1	Start: ESU Troubleshooting.	Begin troubleshooting process for a work order on ESU.
2	Is the ESU free of any external damage/defects?	Check for dents, scratches and any other noticeable problems with the cover or casing.
3	Identify and replace damaged switches, indicators, knobs.	The easiest damages to fix are those on the exterior of the device. See BTA skills on Mechanical Casing and Mechanical Attachment.
4	Clean device using alcohol.	Generally, a maximum of 70% ethanol solution or clean water should be used. See BTA skills on Mechanical Cleaning.
5	Does the ESU turn on?	Check for visible signs of power reaching the device. Lights, sounds, audible motor whirring, etc are all signs that the device is receiving power.
6	Inspect AC adapter cable and pins for cuts, broken wires, and replace if necessary.	See flowchart for troubleshooting Power Supply, and se BTA skills on Power Supply and Electrical Simple.
7	Identify and replace blown fuse.	See flowchart for troubleshooting Power Supply, and se BTA skills on Power Supply and Electrical Simple.
8	Troubleshoot power supply.	See flowchart for troubleshooting Power Supply, and se BTA skills on Power Supply and Electrical Simple.
9	Is the device free from any alarm sound or the device doesn't turn off by itself when in use?	Alarms and sudden power loss are indications that the device is functioning improperly.
10	Ensure proper placement of ground electrode on patient.	
11	Ensure low patient impedance.	
12	Inspect cable connecting the ground electrode to ESU for cuts, broken wires, damage and replace if necessary.	See BTA skills on Power Supply Plug/Cable and Electrical Connections Simple
13	Test ESU using a piece of meat.	Power device as normal, attach electrode to one side of a piece of raw meat and touch ESU pencil to the meat.
14	Are there no cuts on the meat?	Burn marks or cuts underneath the pencil and return electrode are signs that the device is functioning. Lack of these marks mean that the electrodes are not being charged properly
15	Perform preventative maintenance on ESU. Return ESU to clinical personnel.	Device is ready for use.
16	Does the device use monopolar electrodes?	Monopolar electrodes are used when the generator of the device sends a current from one electrode, through tissue, and to the other. When the device uses and ESU pencil and a large, flat, metal return electrode, the device uses monopolar electrodes.
17	Are the bipolar electrodes properly insulated?	Bipolar electrodes are both contained in the tip of the ESU pencil and they pass current between them on a much smaller scale. The exterior of the bipolar electrodes must be insulated to localize energy and current transfer between the electrodes.
18	Ensure proper insulation between the two active	

	(bipolar) electrodes.	
19	Does the return electrode have two sections?	Is the face of the return electrode segmented into two sections?
20	Is the return electrode free from any short circuits between the two sections?	Use a multimeter to measure the resistance or voltage drop between the two sections. See BTA skills on Electrical Simple.
21	Replace return electrode if necessary.	This step would require a readily available replacement part or the device cannot function.
22	Go to step 24.	Proceed to step 24.
23	Is the return electrode flat?	The return electrode must be flat in order to function properly.
24	Is the footswitch pedal properly connected to the device?	See BTA skills for Mechanical Attachment and Mechanical Casing.
25	Inspect for cuts, broken wires in the cable and replace if necessary.	See BTA skills for Electrical Connections.
26	Is the ESU pencil free of any damage/defects?	The ESU pencil is a small metal electrode. Visually and tactilely scan it for obvious damage.
27	Inspect pencil cable and connectors for cuts, broken wires and replace if necessary.	See BTA skills for Electrical Connections and Electrical Connectors.
28	Replace pencil tip if disposable.	This step hinges on the assumption that tips are readily available.
29	Device is ready for use.	Device is ready for use.

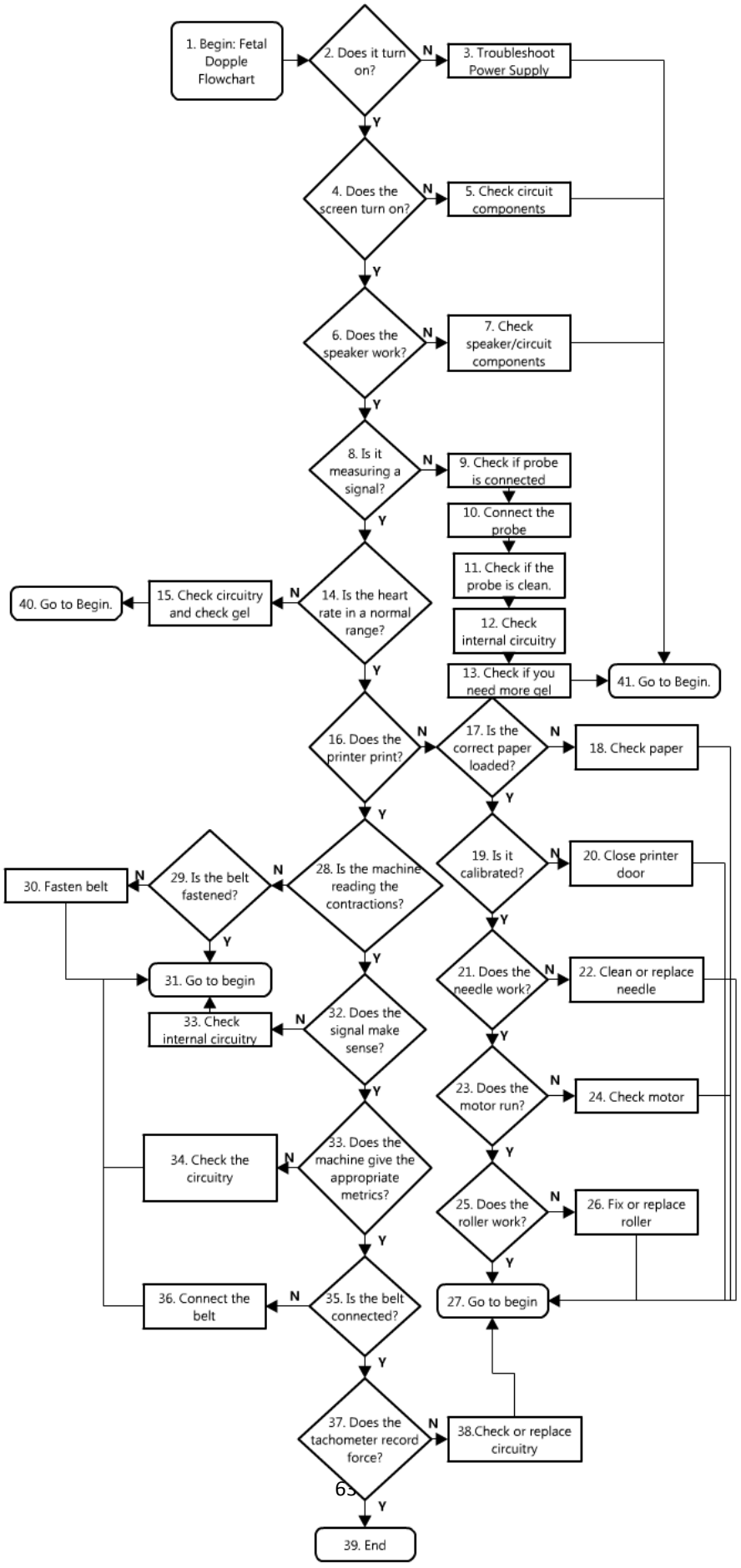
Preventive Maintenance

- Clean and care for electrodes and ESU pencil. Make sure they are free from debris, dirt and damages.
- Check and store wires and cables properly.

Thoughts/ Comments/ Ideas

Fetal Doppler

Flowchart



Description

	Textbox	Explanation
1	Begin Fetal Doppler Flow Chart	Begin diagnostic process for a work order on Fetal Doppler
2	Does it turn on?	Does it turn on?
3	Trouble shoot Power Supply	See Flowchart on Power Supply, and BTA skills on Power Supply.
4	Does the screen turn on?	Does the screen turn on?
5	Check circuit components	Troubleshoot the electrical components. See BTA skills on Electrical Simple.
6	Does the speaker work?	Is sound audible?
7	Check speaker/ circuit components	Troubleshoot the electrical components. See BTA skills on Electrical Simple.
8	Is it measuring a signal?	Is the monitor/Doppler producing HR sound?
9	Check if probe is connected	Check if the probe is connected to the fetal doppler/monitor.
10	Connect the probe	Connect the probe. See BTA skills on Mechanical – Attachments.
11	Check if probe is clean	Clean the probe. See BTA skills on Cleaning.
12	Check internal circuitry,	Troubleshoot the electrical components. See BTA skills on Electrical Simple.
13	Check if you need more gel	Apply ultrasound gel to the probe.
14	Is the heart rate in a normal range?	Is the heart rate in a normal range?
15	Check circuitry and check gel	Troubleshoot the electrical components and apply ultrasound gel to the probe as necessary. See BTA skills on Electrical Simple.
16	Does the printer print?	Is there a marking on the paper?
17	Is the correct paper in>	Do you have the proper thermal paper?
18	Check paper	Check to see whether paper is full.
19	Is it calibrated?	Is the proper Heart Rate, timing, and contraction output? Is the proper calibration signal upon start?
20	Close printer door	Close door.
21	Does the needle work?	Does the needle work?
22	Clean or replace needle	Clean or replace needle. See BTA skills on Mechanical.
23	Does the motor run?	Does the motor rotate?
24	Check motor	See motor guide and BTA skills on Motors.
25	Does the roller work?	Does the roller move the paper at the correct rate without slipping? Are there cracks or damage to the roller? Is the roller hard and showing signs of age?
26	Fix or replace Roller	Fix or replace Roller.
27	Go to begin.	Go to begin.
28	Is the machine reading the contractions?	Does the machine show numbers for the uterine contractions?

29	Is the belt fastened?	Is the belt fastened?
30	Fasten belt.	Fasten belt.
31	Go to begin.	Go to begin.
32	Does the signal make sense?	Does the uterine contraction signal correlate with the contractions the mother is having?
33	Does the machine give the appropriate metrics?	Does the machine output sensible numbers for contraction force and frequency?
34	Check the circuitry.	Troubleshoot the electrical components. See BTA skills on Electrical Simple.
35	Is the belt connected?	Is the belt connected to the fetal monitor?
36	Connect the belt.	Connect the belt.
37	Does the tachometer record force?	Does the tachometer record force numbers?
38	Replace or check circuitry.	Replace the contraction belt or troubleshoot the circuit (see troubleshooting guide)
39	End	End the flow chart.
40	Go to begin.	Go to begin.
41	Go to begin.	Go to begin.

Preventive Maintenance

Fetal Doppler/Monitor Preventative Maintenance

1. Clean the probe before every use to disinfect.
2. Clean the probe and cable after every use with a damp cloth to remove gel.
3. Check the batteries periodically to ensure no corrosion and proper charge.

Fetal Doppler Proper usage guidelines

1. Remove the battery if not in use for an extended period.
2. When cleaning the probe prior to use, use a sort non-abrasive cloth or disposable wipe soaked in disinfectant. Avoid aerosol disinfectants or solutions containing organic solvents or alcohol. Then wipe the probe with a non-abrasive cloth soaked in water. Finally dry the probe and package in a clean bag, covered tray or other way or careful storage and transport.
3. To sterilize the Fetal Doppler or probes, use cold gas sterilization such as ethylene oxide at less than 140 ^{o}F or the Sterad System.
4. Store at a temperature between -10^{o}C and 60^{o}C with a humidity of between 15 and 90%.

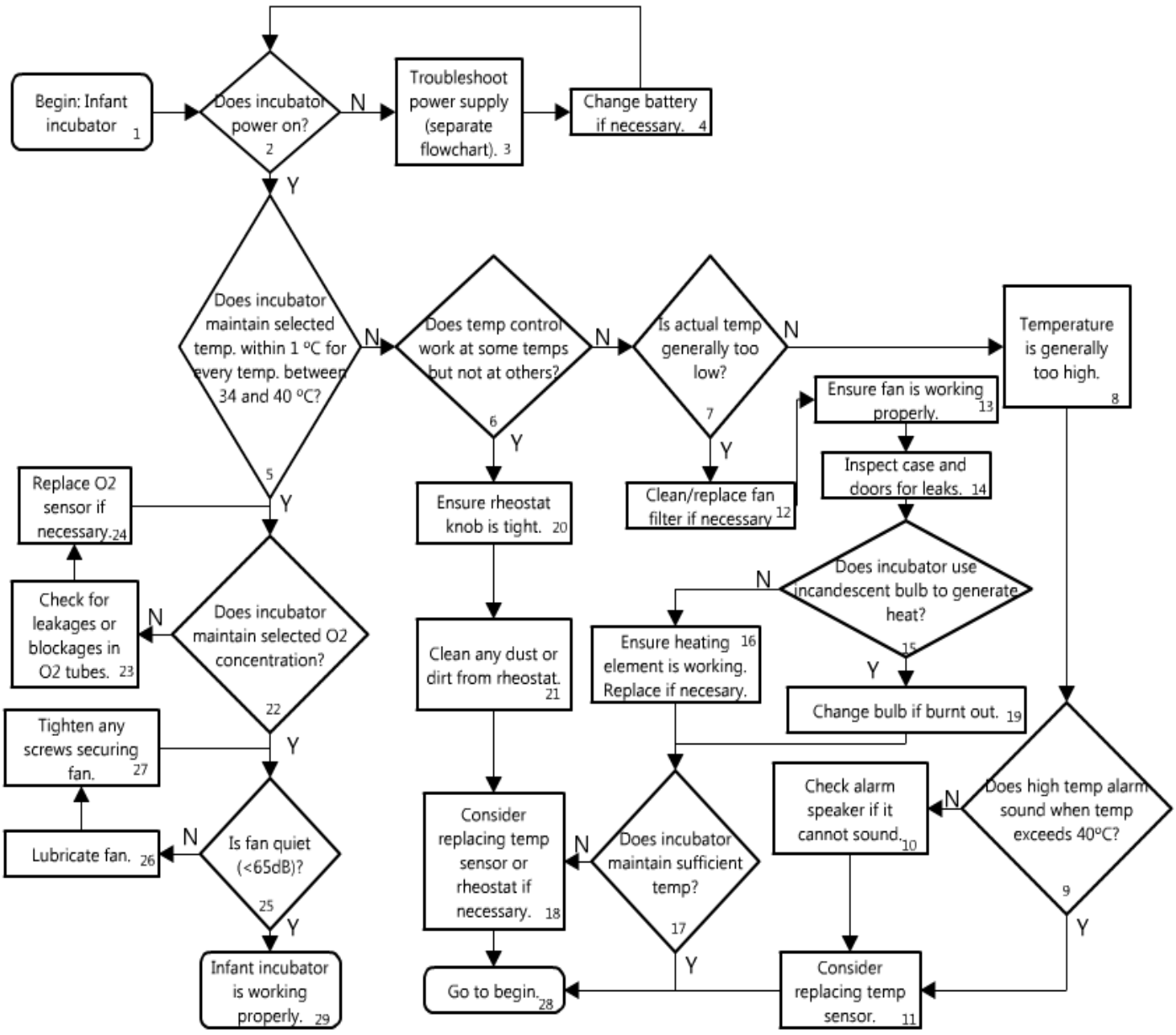
Printer Usage

- For Thermal Paper (must use company provided paper)
    - Thermal side facing up
    - Make sure plastic cover and sticky tab are removed
    - Printer door must be closed correctly
    - 30-240 BPM (USA) scale or 50-210 BPM scale (foreign)

Thoughts/ Comments/ Ideas

Infant Incubator

Flowchart



Description

#	Text box	Explanation or Comment
1	Begin: Infant incubator	Start the diagnostic process for a work order on an infant incubator.
2	Does incubator power on?	Lights, displays, and sounds are signs the device is powered on.
3	Troubleshoot power supply (separate flowchart).	Infant incubators generally have an AC-DC power supply. See Flowchart on Power Supply, or BTA skills on Power Supply.
4	Change battery if necessary.	If there is battery, test its ability to receive and hold a charge. See BTA skills on Batteries.
5	Does incubator maintain selected temperature within 1ºC for every temperature between 34 and 40ºC?	An infant incubator should maintain preset temperatures between 34 and 40ºC. First test to see if the temperature is between these limits. Second, ensure temperature increases and decreases with the control knob or selector. Third, ensure the temperature inside the incubator is within one degree of the value set by the knob or control panel. It may be necessary to use an external thermometer.
6	Does temperature control work at some temperatures but not at others?	The incubator does not pass the third test of controlling temperature to within one degree at all temperatures. Does the temperature increase and decrease with controls, but not maintain the correct temperature at all selected temperatures?
7	Is actual temperature generally too low?	The incubator cannot accurately control the temperature at any temperature level. Is the actual temperature generally lower than the setting?
8	Temperature is generally too high.	The incubator cannot accurately control temperature at any level and the temperature is not too low. Therefore, the temperature is generally too high.
9	Does high temperature alarm sound when temperature exceeds 40ºC?	Does a safety alarm sound when the actual temperature exceeds 40ºC? Alarm is likely to be a sound though it may include a light or flashing display.
10	Check alarm speaker if it cannot sound.	Ensure the machine is not in silent mode. If the machine is not in silent mode and no alarm sounds at high actual temperatures check the temperature sensor placement and the speaker.
11	Consider replacing temperature sensor.	The incubator's temperature is too high and the machine is having trouble regulating the temperature with controls. Check the connections and placement for the machine's temperature sensor. It might not be located in the correct area of the incubator to read the high temperatures. See BTA skills on electrical connections and connectors. If the technical issue cannot be resolved, consult with clinical staff. If the clinical staff approves, they might be able to operate the incubator with a separate thermometer and turn the entire machine off and on to regulate the temperature and prevent it from overheating the infant.

12	Clean/replace fan filter if necessary.	Low temperature can result from problems with the intake fan or from leaks. Fan filter needs to be cleaned or replaced periodically when dirty. The filter might be washable with water and detergent.
13	Ensure fan is working properly.	Use a multimeter to ensure the proper voltage reaches the fan.
14	Inspect case and doors for leaks.	Large leaks can be detected by using your hand to sense warm air escaping. Small leaks can be found by using a toothbrush to apply detergent around seals in doors and case. See BTA skills for Plumbing Leaks. Leaks might be repaired with sealant.
15	Does incubator use incandescent bulb to generate heat?	Some older incubators use an incandescent bulb to generate heat instead of a heating element.
16	Ensure heating element is working. Replace if necessary.	If a resistive heating element is used, measure its resistance with a multimeter and compare to manufacture specifications. The element can be replaced with any resistor with the same resistance and power ratings. See BTA skills on Connections.
17	Does incubator maintain sufficient temperature?	Does the incubator maintain sufficient temperature after any corrective actions on the bulb or heating element?
18	Consider replacing temperature sensor or rheostat if necessary.	If the temperature controls work only at some temperatures, or if the bulb and heating element are both working and the temperature is still too low, there might be a problem with the incubator's temperature sensor not accurately reading the temperature. Check its connections (see BTA skill on electrical Connections). Consider replacing temperature sensor or rheostat.
19	Change bulb if burnt out.	If the incandescent bulb is burnt out it will need to be replaced with one with the same power rating.
20	Ensure rheostat knob is tight.	Some rheostats include a knob that is affixed to the shaft with a set screw. Ensure the screw is tight. If the knob is broken, search for another plastic knob that can replace it. If no knob can be found, it might be possible to control the rheostat using pliers to turn the shaft. See BTA skills on Mechanical Attachment.
21	Clean any dust or dirt from rheostat.	See BTA skills on Cleaning and Repairing Switches.
22	Does incubator maintain selected O2 concentration?	O2 concentration can be measured with a sensor or with an EWH skill using locally available resources. Contact EWH for more information.
23	Check for leakages or blockages in O2 tubes.	See BTA skills on Plumbing Leaks and Blockages.
24	Replace O2 sensor if necessary.	The O2 sensor may not be accurately reading the oxygen concentration. See BTA skills on Electrical Connections.

25	Is fan quiet (<65dB)?	The fan should not be excessively noise (below 65 db). Assuming you don't have a sound meter with you, try to estimate the noise of the fan with your own ear placed where the baby's will be. It should be so quiet that you could comfortably hear all the conversations in the room around you.
26	Lubricate fan.	A noisy fan may need lubrication. See BTA skills on Motor Cleaning and Lubrication.
27	Tighten any screws securing fan.	A noisy fan might be unbalanced or insecure. See BTA skills on Mechanical Attachments.
28	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
29	Infant incubator is working properly.	Return the machine to service via the appropriate clinical personnel.

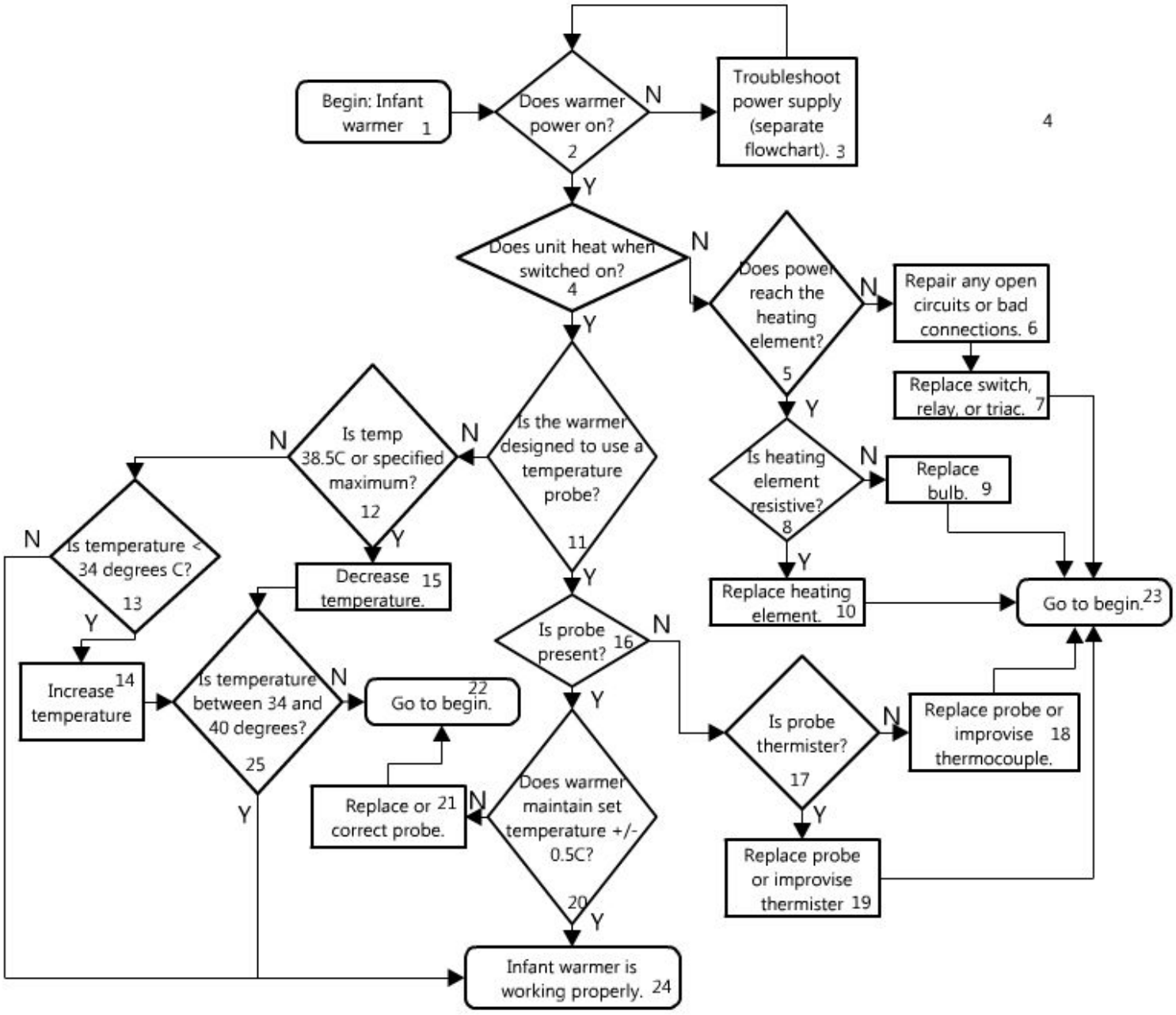
Preventative Maintenance

1. Clean humidification chamber.
2. Check seals around doors and ports.
3. Lubricate fan and tighten bolts to prevent noise.
4. Clean or replace bacterial filter on air intake (this is needed more frequently in dusty environments).
5. Clean incubator (use warm water, detergent, and antiseptic only).
6. Ensure doors and ports stay shut when latched.
7. Check electrical plug.
8. Check that cradle tilt is working and adjustable.
9. Drain and dry tray. Refill with sterile water immediately before re-use. Change water daily.
10. Check O2 circuit connections and O2 concentration inside unit.
11. Inspect wheels/casters.
12. Clean air intake filter with detergent if washable and necessary.
13. Check leakage current (<300 microamps).
14. Check ground resistance (<0.5 ohms).
15. Search for air leaks on case, especially at junctions or joints of different plates or pieces (using detergent and toothbrush while unit is sealed can reveal leaks).
16. Check for evidence of fluid spills and clean any found spills.
17. Verify controls and switches are operating properly.
18. Check for unusual noise or vibration.
19. Test audible and visible alarms and indicators.

Thoughts/Comment/Ideas

Infant Warmer

Flowchart



Description

#	Text Box	Comments
1	Begin: Infant warmer	Begin diagnostic process for infant warmer.
2	Does warmer power on?	Lights, displays, and sounds are all indications that the device has powered on.
3	Troubleshoot power supply (separate flowchart)	Most infant warmers have AC-DC power supplies. See Flowchart for Power Supply and BTA skills on Power Supply.
4	Does unit heat when switched on?	Does the device produce heat when the warmer is switched on?
5	Does power reach the heating element?	If no heat is produced, use a multimeter to test if the proper voltage is reaching the heating element.
6	Repair any open circuits or bad connections.	If power does not reach the heating element, there might be an open circuit, bad connection, or broken wire. See BTA skills on Electrical Connections.
7	Replace switch, relay, or triac.	A switch, relay, or triac may be used to control current flow to the heating element. Ensure it is working properly. See BTA skills on Electrical Switches.
8	Is heating element resistive?	Infant warmers typically use a resistive element or a bulb to create heat. Check which one is used in this device.
9	Replace bulb.	If a bulb is used and the proper voltage is reaching the bulb, it must be replaced. See BTA skills on Electrical Lighting.
10	Replace heating element.	If a resistive element is used and the proper voltage is reaching the resistor, the element must be replaced. See BTA skills on Electrical Heating Element.
11	Is the warmer designed to use a temperature probe?	If the warmer heats, it's necessary to check the temperature control methods of the device. Is a temperature probe (thermometer) used, either on the skin of the infant or in the air?
12	Is temperature > 38 degrees C?	If there is no thermometer, the temperature must be measured at patient level to ensure it stays at the desired level (typically between 34 and 38 degrees C).
13	Is temperature < 34 degrees C?	If the temperature is below 38 degrees C, confirm that is above the minimum temperature (34 degrees C).
14	Increase temperature.	Increase the temperature if it is below 34 degrees C. This might be accomplished by using control knobs to increase heat output, moving the heating element closer to the patient, and/or reducing ventilation.
15	Decrease temperature.	Decrease the temperature if it is above 38 degrees C. This might be accomplished by using the control knob to decrease output of the heating element, moving the element farther from the patient, and/or increasing ventilation.
16	Is probe present?	Confirm that the probe is present. Missing or damaged temperature probes are a common problem. Some warmers may have a manual mode to set a fixed heat output if the temperature probe is missing.

17	Is probe thermistor?	If there is a temperature probe present, it will be either a thermistor or a thermocouple. Attempt to verify which it is.
18	Replace probe or improvise thermocouple.	If the probe is a thermocouple, it works by providing a voltage source that varies in response to the input temperature. A battery and voltage divider might be able to be used to improvise the voltage output at a particular level to convert the infant warmer to manual mode.
19	Replace probe or improvise thermistor	If the probe is a thermistor, it works by providing a resistance that varies in response to the input temperature. A potentiometer or resistor might be able to be used to improvise the resistance at a particular level to convert the infant warmer to manual mode.
20	Does warmer maintain temp within 1 degree C?	If the probe is present, test the temperature output at various temperature levels to ensure the device can maintain the selected temperature within 1 degree C.
21	Replace or correct probe.	If the device does not maintain a temperature close to the input, the probe must be replaced or corrected.
22	Go to begin.	Begin the diagnostic process again to determine if corrective measures have repaired the device.
23	Go to begin.	Begin the diagnostic process again to determine if corrective measures have repaired the device.
24	Infant warmer is working properly.	The infant warmer maintains the appropriate temperature. The repair was successful.
25	Is temperature between 34 and 38 degrees?	Does the warmer maintain an appropriate temperature (between 34 and 38 degrees C) when operating in manual mode (without a temperature probe)?

Preventive Maintenance

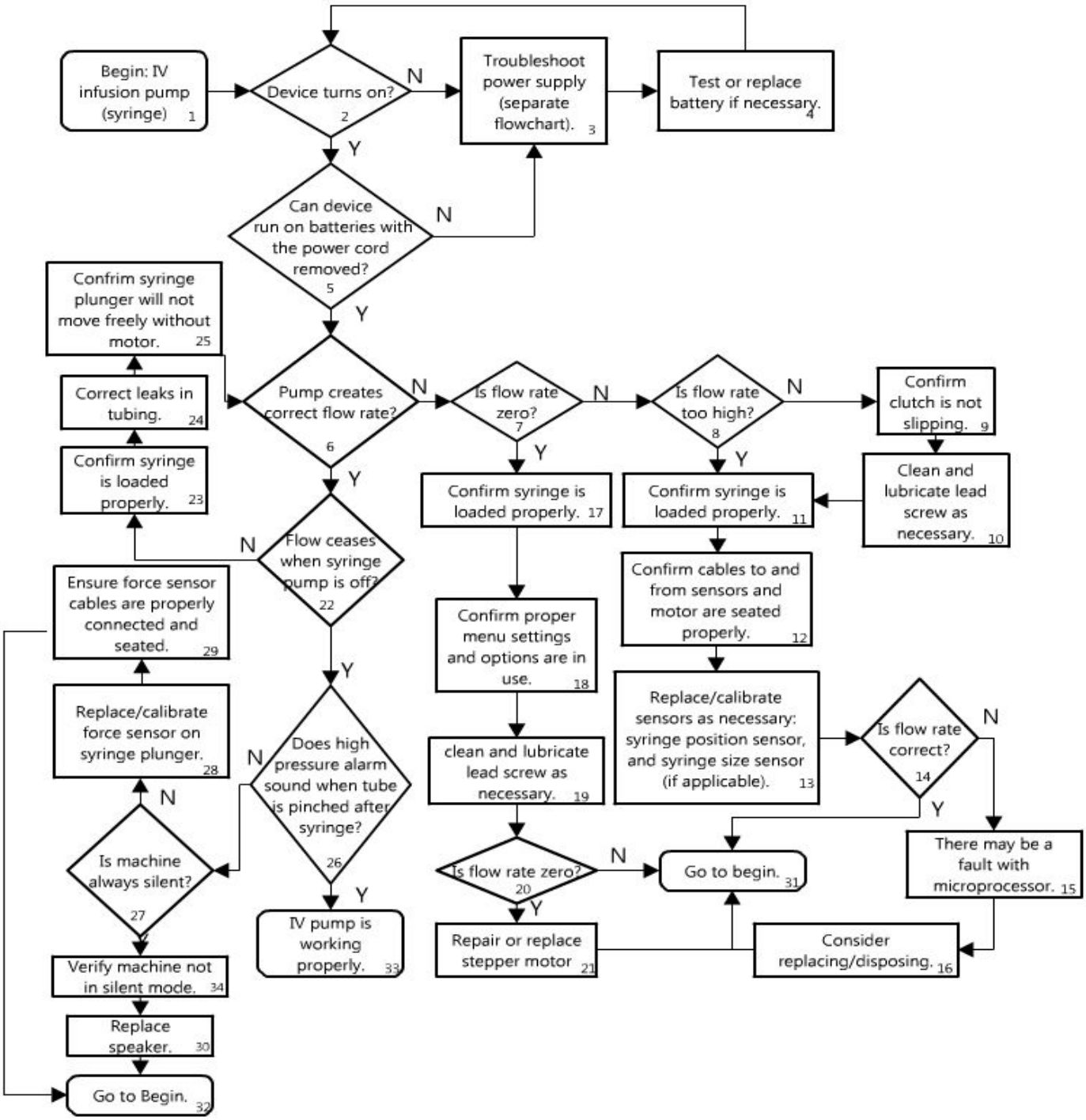
- Check for signs of physical damage or abuse especially concerning the heater(s) elements.
- Check for evidence of fluid spills
- Check for secure mounting
- Check casters/brakes/mounting
- Check AC plug/cord/receptacle
- Check strain relief at both ends of cord
- Check controls/switches
- Check caution/operation labels present & legible
- Check filters. Clean/replace as needed
- Check power-on sequence
- Test all audible & visual alarms and indicators
- Clean interior/exterior as required
- Test HI Temp Alarm
- Measure temperature at a minimum of 2 set temperatures. Check high temperature alarm. Measure chassis ground resistance
- Measure chassis leakage current
- Check battery
- Check that the unit is clean and disinfected prior to use.
- Clean skin temp sensor
- Check for corrosion and tightness of the heating element connections.

Thoughts/ Comments/ Ideas

Infusion Pump (Syringe)

Flowchart

This type of infusion pump uses a syringe driven by a lead screw to deliver precise amounts of liquid medication intravenously.



Description

#	Text Box	Comments
1	Begin: IV infusion pump (syringe)	Start the diagnostic process for a work order on an Infusion pump (syringe).
2	Device turns on?	Displays, lights, and sounds are all indications the machine has turned on.
3	Troubleshoot power supply (separate flowchart).	Syringe pumps generally have an AC-DC power supply. See flowchart on Power Supply and BTA skills on Power Supply.
4	Test or replace battery if necessary.	Old batteries are a common problem with syringe pump batteries. See BTA skills for Batteries.
5	Device runs on battery only (no AC)?	Check if the machine will run on battery when power is unplugged. This is a safety feature on nearly all syringe pumps.
6	Pump creates correct flow rate?	Measure the flow rate using a container of known-volume to collect the fluid and a stopwatch. For small flow rates, it may be necessary to use a precision scale to measure the fluid output. Flow rate is volume divided by time.
7	Is flow rate zero?	Check if the machine will generate any output of fluid.
8	Is flow rate too high?	Compare the measured flow rate to the amount programmed in the machine.
9	Confirm clutch is not slipping.	Low flow can be caused by a clutch slipping on the lead screw. Repair slip if necessary.
10	Clean and lubricate lead screw as necessary.	See BTA skills on Cleaning and Lubrication.
11	Confirm syringe is loaded properly.	Incorrect flow rate can be caused by improperly loaded syringe.
12	Confirm cables to and from sensors and motor are seated properly.	See BTA skills on Electric Connections.
13	Replace/calibrate sensors as necessary: syringe position sensor, and syringe size sensor (if applicable).	Faulty sensors can cause faults in controlling the flow rate.
14	Is flow rate correct?	Measure the flow rate using a container of known-volume to collect the fluid and a stopwatch. For small flow rates, it may be necessary to use a precision scale to measure the fluid output.
15	There may be a fault with microprocessor.	If corrective measures don't resolve the incorrect flow rate, a problem with the microprocessor or computing software is possible.
16	Consider replacing/disposing.	If the problem lies with the microprocessor, the machine may need to be disposed.
17	Confirm syringe is loaded properly.	Incorrect flow rate can be caused by improperly loaded syringe.

18	Confirm proper menu settings and options are in use.	User error may be a problem if machine is reported for lack of flow.
19	Clean and lubricate lead screw as necessary.	See BTA skills on Cleaning and Lubrication.
20	Is flow rate zero?	Check if the machine will generate any output of fluid.
21	Repair or replace stepper motor.	If corrective measures don't start fluid output, there may be a problem with the motor that drives the syringe. See BTA skills on Motors.
22	Flow ceases when syringe pump is off?	Verify that the flow ends when the pump is turned off or the control panel is used to end the flow.
23	Confirm syringe is loaded properly.	An incorrectly loaded syringe could leak fluid when flow is turned off by controls.
24	Correct leaks in tubing.	See BTA skills on Plumbing Leaks.
25	Confirm syringe plunger will not move freely without motor.	If plunger moves independently of machine controls, check mechanical connections. See BTA skills on Mechanical Attachment.
26	Does high pressure alarm sound when tube is pinched after syringe?	If the output tube is occluded, the machine should emit a high pressure alarm.
27	Is machine always silent?	Investigate if machine makes noises due to any other inputs or alarms.
28	Replace/calibrate force sensor on syringe plunger.	High pressure alarm is not sounding. Check the force sensor that measures the force applied to the syringe plunger.
29	Ensure force sensor cables are properly connected and seated.	See BTA skills on Electric Connections and Connectors.
30	Replace speaker.	Machine is not in silent mode, but it does not make noise. Replace the speaker.
31	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
32	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
33	IV pump is working properly.	Return the machine to service via the appropriate clinical personnel.
34	Verify machine not in silent mode.	Silent mode may be preventing the alarm. Turn off silent mode and check alarm again.

Preventative Maintenance

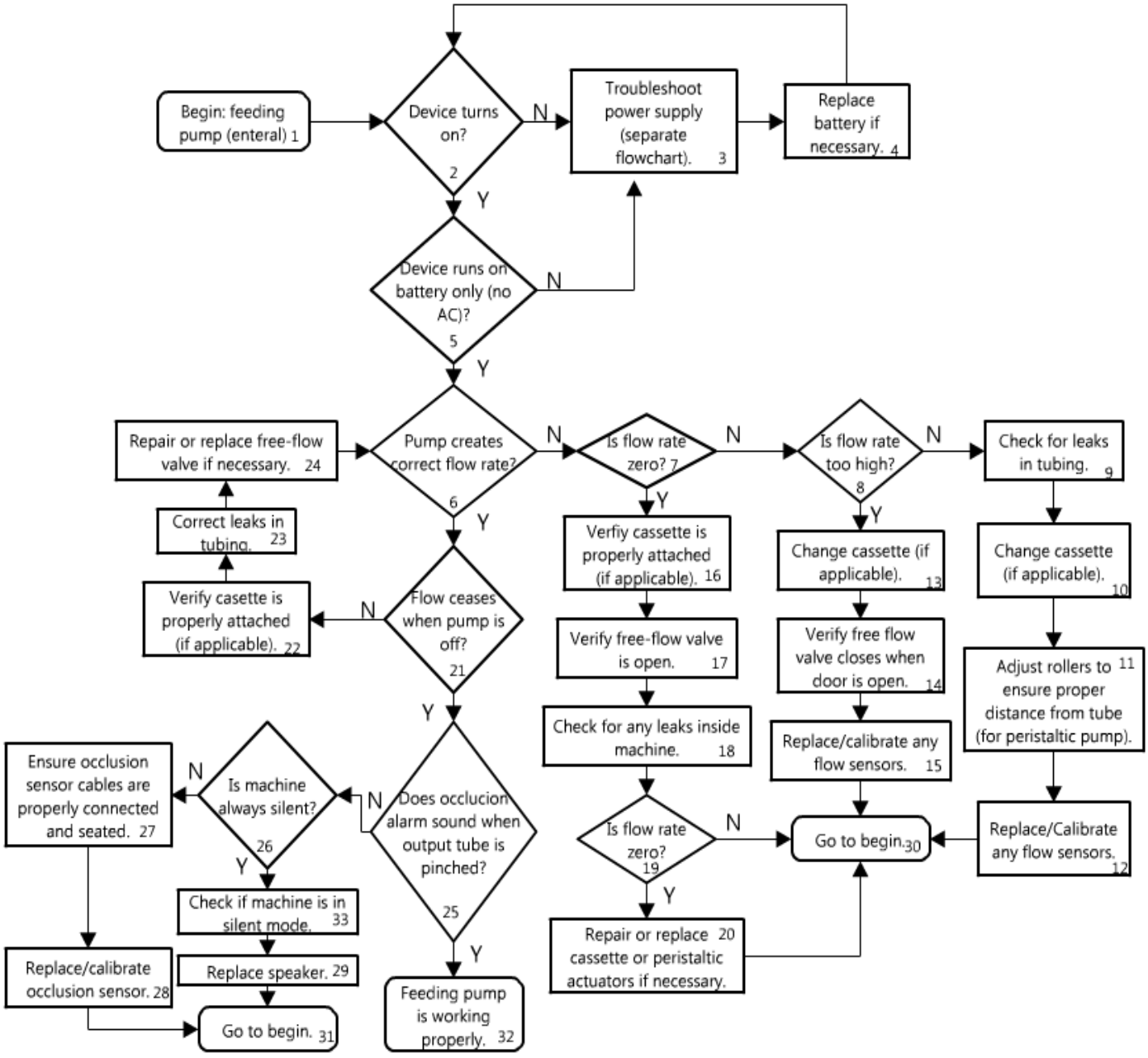
- Examine plug and line cord.
- Examine internal cables and connectors.
- Verify software and menu settings are appropriate for clinical application.
- Examine controls and switches for proper function.
- Verify battery chargers and indicators are working
- Check suggested replacement date for the battery to see if the date is passed or approaching.
- Confirm lights, indicators, and displays are working.
- Verify flow stops when device is turned off.
- If device includes a feature that requires the IV set to be closed before it is disconnected (either automatically or manually), verify that this mechanism is operating properly.
- Calibrate machine for flow rate.
- Replace battery if necessary.
- Check for unusual noise or vibration.
- Run self-test, if equipped.
- Lubricate lead screw, gears, and other moving parts as required.
- Measure chassis leakage current.
- Measure ground resistance.
- Test audible and visual alarms and indicators.

Thoughts/ Comments/ Ideas

Infusion Pump (Feeding)

This type of infusion pump delivers higher volumes of nutritional fluid enterally. This chart includes enteral pumps working with two basic mechanisms: a peristaltic pump using actuated “fingers” to pump fluid through a flexible tube and a cassette pump, in which the pumping is achieved by a cassette as part of a circuit that detaches from the machine.

Flowchart



Description

#	Text Box	Comments
1	Begin: feeding pump (enteral)	Start the diagnostic process for a work order on a feeding pump.
2	Device turns on?	Lights, displays, and sounds are signs the device is powered on.
3	Troubleshoot power supply (separate flowchart).	Feeding pumps generally have an AC-DC power supply. See flowchart on Power Supply and BTA skills on Power Supply.
4	Replace battery if necessary.	Old batteries are a common problem with feeding pumps. Test battery's ability to receive and hold a charge. See BTA skills on Batteries.
5	Device runs on battery only (no AC)?	Check if the machine will run on battery when power is unplugged. This is a safety feature on nearly all feeding pumps.
6	Pump creates correct flow rate?	Measure the flow rate using a container of known-volume to collect the fluid and a stopwatch. Flow rate is volume divided by time.
7	Is flow rate zero?	Check if the machine will generate any output of fluid.
8	Is flow rate too high?	Compare the measured flow rate to the amount programmed in the machine.
9	Check for leaks in tubing.	Tubing leaks can cause low flow rate. See BTA skills on Plumbing Leaks.
10	Change cassette (if applicable).	Some feeding pumps use a cassette or pump set as an accessory that must be changed and refilled periodically. Sometimes the cassette must be “primed” or “reset” using menu options on the machine after refilling.
11	Adjust rollers to ensure proper distance from tube (for peristaltic pump).	For peristaltic feeding pumps, incorrect flow rates can result from rollers that are either too far or too close to the tube.
12	Replace/calibrate any flow sensors.	Incorrect flow rates can be caused by faulty or disconnected flow sensors. See BTA skill on Electrical Connections and Connecters.
13	Change cassette (if applicable).	Some feeding pumps use a cassette or pump set as an accessory that must be changed and refilled periodically. Sometimes the cassette must be “primed” or “reset” using menu options on the machine after refilling.
14	Verify free flow valve closes when door is open.	Some feeding pumps, especially peristaltic feeding pumps, have a free-flow valve that closes to prevent flow when the machine case is open. Ensure the valve is working properly and clean it or adjust it mechanically if necessary. See BTA skills on Plumbing.
15	Replace/calibrate any flow sensors.	Incorrect flow rates can be caused by faulty or disconnected flow sensors. See BTA skill on Electrical Connections and Connecters.
16	Verify cassette is properly attached (if applicable).	An improperly loaded cassette or pump set can prevent any fluid output.

17	Verify free-flow valve is open.	The free-flow valve must be open to allow fluid output. Ensure the valve is working properly and clean it or adjust it mechanically if necessary.
18	Check for any leaks inside machine.	A leak in the tubing can cause a spill and prevent flow. See BTA skills on Plumbing Leaks.
19	Is flow rate zero?	Check if the machine will generate any output of fluid.
20	Repair or replace cassette or peristaltic actuators if necessary.	Some feeding pumps use a cassette or pump set as an accessory that must be changed and refilled periodically. Sometimes the cassette must be “primed” or “reset” using menu options on the machine after refilling. Peristaltic pumps use rollers that are controlled and moved by electromechanical actuators. Lubricate or replace the actuators as necessary.
21	Flow ceases when pump is off?	When the flow is turned off by unplugging the machine or via user controls, verify that the fluid output stops.
22	Verify cassette is properly attached (if applicable).	An improperly loaded cassette or pump set might leak fluid after the device is turned off.
23	Correct leaks in tubing.	See BTA skill on Plumbing Leaks.
24	Repair or replace free-flow valve if necessary.	Ensure the free-flow valve is working properly and clean it or adjust it mechanically as necessary. See BTA skills on Plumbing.
25	Does occlusion alarm sound when output tube is pinched?	When the output tube is occluded, the machine should sound.
26	Is machine always silent?	Investigate if machine makes noises due to any other inputs or alarms.
27	Ensure occlusion sensor cables are properly connected and seated.	See BTA skills on Electric Connections and Connectors.
28	Replace/calibrate occlusion sensor.	See BTA skills on Electric Connections and Connectors. Consider replacing sensor if it cannot be repaired.
29	Replace speaker.	Machine is not in silent mode, but it does not make noise. Replace the speaker.
30	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
31	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
32	Feeding pump is working properly.	Return the machine to service via the appropriate clinical personnel.
33	Check if machine is in silent mode.	Silent mode may be preventing the alarm. Turn off silent mode and check alarm again.

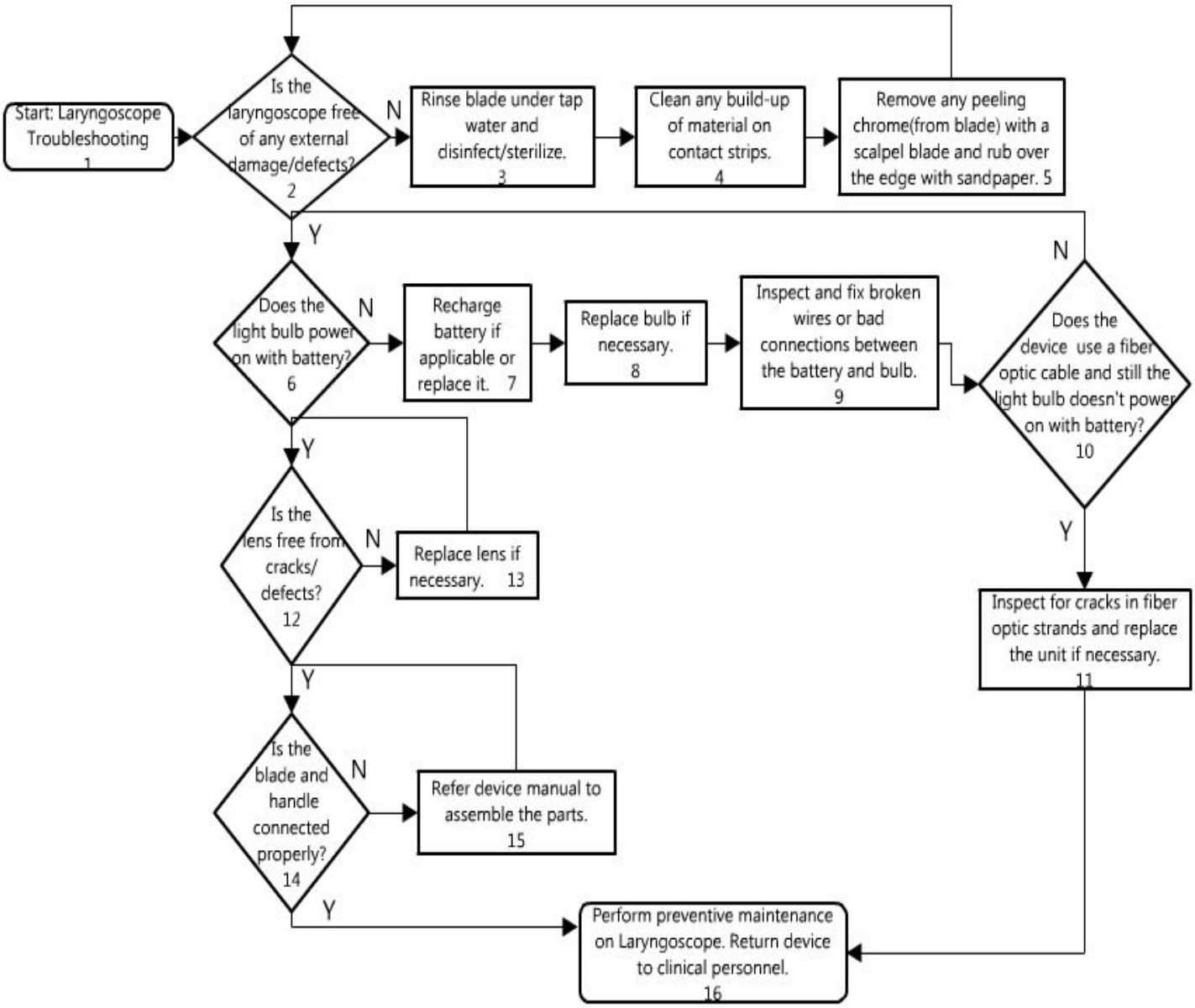
Preventative Maintenance

- Clean machine and chassis from any enteral solution residue.
- Examine plug and line cord.
- Examine internal cables and connectors.
- Verify software and menu settings are appropriate for clinical application.
- Examine controls and switches for proper function.
- Verify battery chargers and indicators are working.
- Check suggested replacement date for the battery to see if the date is passed or approaching.
- Confirm lights, indicators, and displays are working.
- Verify flow stops when device is turned off.
- Calibrate machine for flow rate.
- Replace battery if necessary.
- Check for unusual noise or vibration.
- Check rollers and tubing to see if replacement is necessary.
- Run self-test, if equipped.
- Lubricate any rollers or actuators as necessary.
- Measure chassis leakage current.
- Measure ground resistance.
- Test audible and visual alarms and indicators.

Thoughts/ Comments/ Ideas

Laryngoscope

Flowchart



Description

#	Text Box	Comments
1	Start: Laryngoscope Troubleshooting	Begin diagnostic process for a work order for Laryngoscope.
2	Is the laryngoscope free of any external damage/defects?	Inspect laryngoscope for external cracks, damage, or dirt.
3	Rinse blade under tap water and disinfect/sterilize.	Clean and dry the blade.
4	Clean any build-up of material on contact strips.	Examine the contact strips (blade-handle interface) of laryngoscope for dirt.
5	Remove any peeling chrome (from blade) with a scalpel blade and rub over the edge with sandpaper.	Examine the blade for any peeling chrome and remove peels with care. Ensure that there is no damage to the blade during the removal process.
6	Does the light bulb power on with battery?	Power on the device with battery. Examine whether light bulb gives sufficient illumination.
7	Recharge battery if applicable or replace it.	Refer BTA skill set on Batteries to identify and replace damaged batteries.
8	Replace bulb if necessary.	Refer BTA skill set on Lighting/Indicators to replace non-functional light bulbs.
9	Inspect and fix broken wires or bad connections between the battery and bulb.	Inspect wires and connections from battery to bulb using multimeter. Refer BTA skill set on Connections for identifying and fixing broken wires and bad connections.
10	Does the device use a fiber optic cable and still the light bulb doesn't power on with battery?	There are two types of laryngoscopes: • Conventional laryngoscope • Fiber optic laryngoscope If the bulb still doesn't power on then there might be cracks in the fiber optic strands. So the unit might have to be replaced.
11	Inspect for cracks in fiber optic strands and replace the unit if necessary.	If the illumination is not sufficient then inspect for cracks in fiber optic strands.
12	Is the lens free from cracks/defects?	Any defect in the lens obstructs vision of larynx and vocal cords.
13	Replace lens if necessary.	Identify and replace with a suitable lens.
14	Is the blade and handle connected properly?	Improper connection between blade and handle may result in faulty operation of the device.
15	Refer device manual to assemble the parts.	Follow instructions in the device manual to assemble the parts.
16	Perform preventive maintenance on Laryngoscope. Return device to clinical personnel.	Laryngoscope is working properly. Perform preventive maintenance before returning the device to clinical personnel.

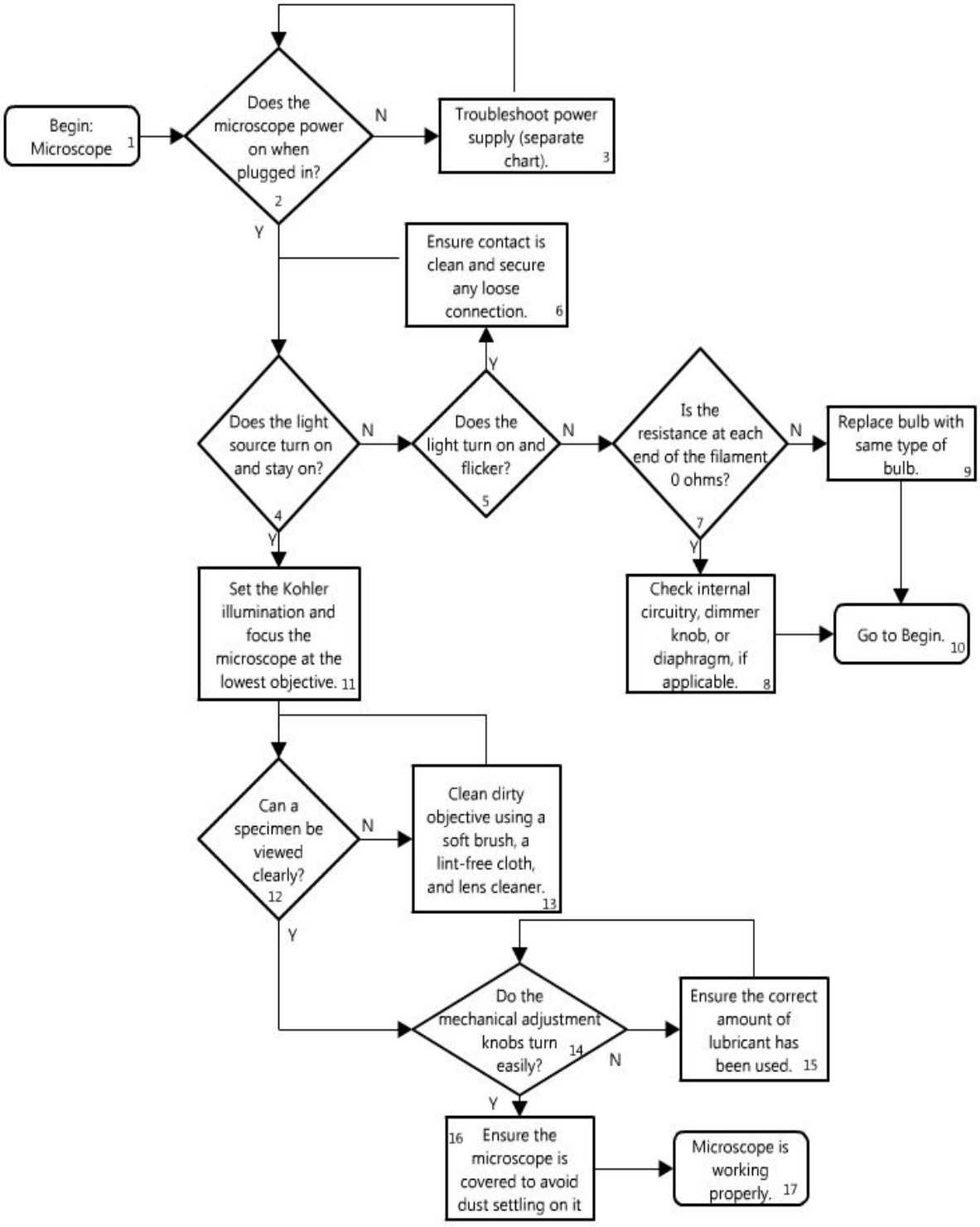
Preventative Maintenance

- Clean/sterilize blades and ensure that there is no build-up or debris on blades or in areas of connection between blade and handle
- Scan lens for cracks
- Keep lens clean of debris using soft cloth and water or ethanol solution
- Check/replace bulb and battery as needed

Thoughts/ Comments/ Ideas

Microscope

Flowchart



Description

#	Text Box	Comments
1	Begin: Microscope	Begin diagnostic process for a work order for Microscope. Maintenance is generally requested on a microscope when a specimen cannot be viewed clearly or at all.
2	Does the microscope power on when plugged in?	When plugged in, the microscope should power on completely.
3	Troubleshoot power supply (separate chart).	If no power reaches the machine, there may be problems with the switch, fuse, power supply components, or wiring. See flowchart on Power Supply and BTA skills on Power Supply.
4	Does the light source turn on and stay on?	The light source should remain constant across the stage when on.
5	Does the light turn on and flicker?	If the light turns on but does not remain constant, there may be a minor problem that can be fixed without replacing the bulb completely.
6	Ensure contact is clean and secure any loose connection.	The inside of the lamp house or the connections may be dirty. The connections should also be secured firmly. See BTA skills for Connections.
7	Is resistance at each end of the filament 0 ohms?	This checks if the filament in the bulb is functioning.
8	Check internal circuitry, dimmer knob, or diaphragm, if applicable.	Ensure that the circuitry that connects to the light source is intact. In addition, ensure the dimmer knob is turned on and that the diaphragm is open.
9	Replace bulb with same type of bulb.	If the light source still does not turn on, replace the bulb with another of the same type. If the same type of bulb is not available, a new source can be wired in. See BTA skills on Replacement of Light Bulbs and Light Fixtures.
10	Go to begin.	Restart the diagnostic process.
11	Focus the microscope at the lowest objective.	Begin this portion of the diagnostic process at the lowest objective.
12	Can the specimen be viewed clearly?	If the specimen is out of focus or cannot be viewed at all, the objectives may need attention.
13	Clean dirty objective using a soft brush, a lint-free cloth, and lens cleaner.	Objectives can be unscrewed or removed for cleaning. Unscrew eyepiece to use as a magnifying glass if one is not available to inspect objective for scratches, nicks, cracks, deterioration of seal around lens or oil seepage into lens. Blow off any dust with canned air before cleaning. Start cleaning objective lens from center and spiral out with cotton swab or cloth. If lens cleaner is not available, ethyl ether, xylene, petrol can be used. Alcohol, acetones or any other ketones should not be used, as they may dissolve sealants.
14	Do the mechanical adjustment knobs turn easily?	The knobs and stage should be able to move freely and also maintain a steady position. The screws holding each in place may need some adjustment.
15	Ensure the correct amount of lubricant has been used.	Clean off excess lubricant (especially if it has dried and is clumping) using a soft cloth dampened with alcohol. Do not use solvents that leave residue or lint on the surface. Dust, clean (with solvent listed above), polish (with metal polish, if available) and lubricate adjustments if they are stuck or difficult to turn.
16	Ensure the microscope is covered to avoid dust settling on it.	When covering the microscope, put a small amount of uncooked rice to prevent fungal growth. Replace uncooked rice weekly.

17	Microscope is working properly.	Return the machine to the appropriate clinical personnel.

Preventative Maintenance

Complete every six months.

- Clean machine with air brush or air blower, lint free cloth with lens cleaner. Start cleaning objective lens from center and spiral out with cotton swab or cloth. If lens cleaner is not available, ethyl ether, xylene, petrol can be used. However, alcohol, acetones or any other ketones should not be used, as they may dissolve the sealants around the lens.
- Check for and remove any present fungal growth.
- Ensure a specimen can be viewed clearly through all objectives. Do not scratch or damage the lens. Oil lens - X100 needs a drop of oil to confirm clear image. Clean all objectives and eyepieces first, and then check for image clarity.
- Check optical alignment.
- Lubricate adjustments.
- Ensure light source is working properly.
- Inspect for signs of damage, scratches, or dirt.
- Examine switches and controls for proper function.
- Replace uncooked rice before storage to prevent fungal growth.

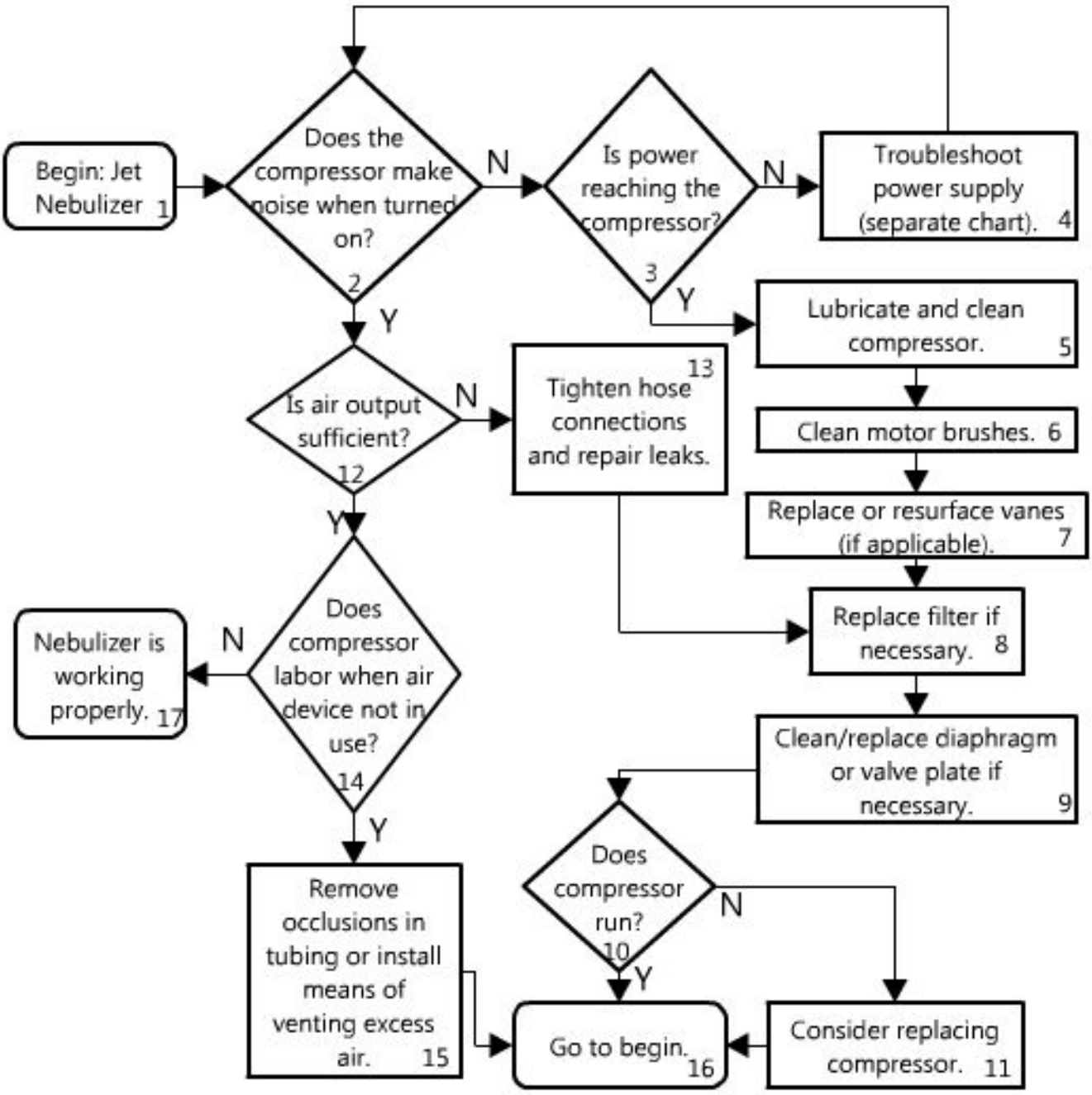
Kohler Illumination: It is a method of illumination which involves optimizing a microscope's optical train to produce homogenously bright light free from artifacts and glare. In Kohler illumination, four separate planes combine to form conjugate planes in both the illumination and image-forming light pathways. The lamp filament, aperture diaphragm, back focal plane of the objective lens, and the eye point which is approximately one centimeter above the top lens of the ocular, form the illumination conjugate plane. The conjugate planes of the imaging light path are the field diaphragm, specimen, the fixed diaphragm of the ocular, and the retinal plane of the viewer. In Kohler illumination the collector lens or field diaphragm collects light from the illumination source and focuses it at the front focal plane of the sub-stage condenser's aperture diaphragm which, in essence, projects an image of the lamp filament onto the lens.

Thoughts/ Comments/ Ideas

Nebulizer (Jet)

Flowchart

A jet nebulizer works by using a compressor to force a jet of air through a container with liquid medication. This converts the liquid medication into a mist for breathing.



Description

#	Text Box	Comments
1	Begin: Jet Nebulizer	Begin diagnostic process for a work order for Jet Nebulizer. Maintenance is generally requested on a jet nebulizer when it is offering weak or no output.
2	Does the compressor make noise when turned on?	A working suction machine has a motor or pump that makes noise when the device is turned on.
3	Is power reaching the compressor?	Wires should enter the motor to provide power. Use a multimeter to determine if the proper voltage is reaching these wires.
4	Troubleshoot power supply (separate chart).	If no power reaches the pump, there may be problems with the switch, fuse, or wiring. If the motor is DC, check the power supply. See flowchart on Power Supply and BTA skills on Power Supply.
5	Lubricate and clean compressor.	See BTA skills on Motors.
6	Clean motor brushes.	See BTA skills on Motor Brushes.
7	Replace or resurface vanes (if applicable).	The vanes on rotary vane pumps may wear out over time. The vanes may be replaced, but are often expensive and difficult to find. They can be lubricated by hand, using motor or compressor oil, if done carefully.
8	Replace filter if necessary.	Nebulizers have an air intake filter that needs periodic replacement. If it appears gray or dirty, look for a replacement.
9	Clean/replace diaphragm or valve plate if necessary.	The diaphragm of a valve plate or membrane pump should be cleaned periodically. See BTA skills on Mechanical Cleaning.
10	Does compressor run?	After each attempt to repair the motor, test to see if it works.
11	Consider replacing compressor.	If the motor can't be repaired, it is time to replace the motor or the entire unit.
12	Is air output sufficient?	Has clinical staff noticed a reduction in air output? Test the air flow by measuring displacement of water from a jar. Typically a nebulizer will displace 18-23 liters/min.
13	Tighten hose connections and repair leaks.	See BTA skills on Plumbing.
14	Does compressor labor when air device not in use?	The motor should not shake or make excessive noise when the air device is not in use.
15	Remove occlusions in tubing or install means of venting excess air.	See BTA skills on plumbing blockages. A pressure regulator could be installed to vent excess air.
16	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
17	Nebulizer is working properly.	Return the machine to service via the appropriate clinical personnel.

Preventive Maintenance

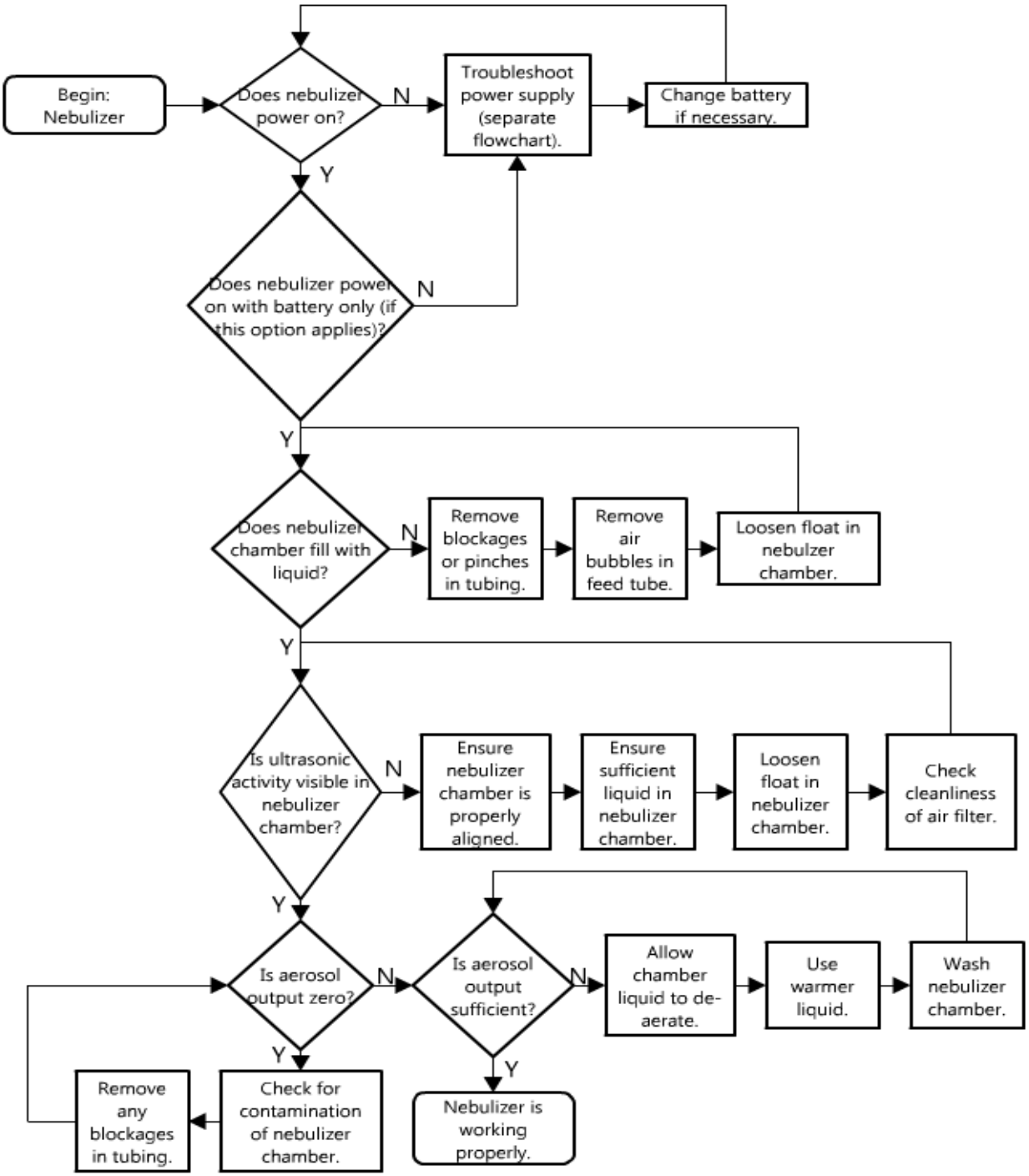
- Inspect exterior of equipment for damaged or missing hardware.
- Inspect the power cord, strain relief and plug/s for any signs of damage.
- Turn unit off, open user accessible covers and inspect unit for damage.
- Clean unit interior components and exterior with vacuum or compressed air.
- Inspect interior for signs of corrosion or missing hardware. Repair as required.
- Inspect electrical components for signs of excessive heat or deterioration.
- Inspect water jet assembly including orifice. Check for water leakage.
- Check gaskets and O-rings.
- Verify correct operation of all buttons, controls, displays and/or indicators.
- Verify correct operation of unit in all functional modalities.
- Clean exterior of unit including all accessories, cables, controls and displays.
- Change air intake filter when it is gray or dirty.

Thoughts/ Comments/ Ideas

Nebulizer (Ultrasonic)

An ultrasonic nebulizer uses a vibrating piezoelectric element. This element creates an ultrasonic wave and is in contact with liquid medication, causing a fine mist with homogenous droplet size.

Flowchart



Description

#	Text Box	Comments
1	Begin: ultrasonic nebulizer	Start the diagnostic process for a work order for ultrasonic nebulizer.
2	Does nebulizer power on?	Lights, displays, and sounds are signs the device is powered on.
3	Troubleshoot power supply (separate flowchart).	Ultrasonic nebulizers generally have an AC-DC power supply. See flowchart for Power Supply and BTA skills on Power Supply.
4	Change battery if necessary.	If there is battery, test its ability to receive and hold a charge. See BTA skills on Batteries.
5	Does nebulizer power on with battery only (if this option applies)?	Check if the machine will run on battery when power is unplugged. Some ultrasound nebulizers may not offer this feature. Disregard this step if there are no batteries.
6	Does nebulizer chamber fill with liquid?	The nebulizer may have a liquid reservoir that fills with the liquid medication. Verify that machine will fill this chamber.
7	Remove blockages or pinches in tubing.	See BTA skills on Plumbing Blockages.
8	Remove air bubbles in feed tube.	Remove the bottle, invert, and replace to get air bubbles out of the tubing.
9	Loosen float in nebulizer chamber.	Ensure float system is loose and moves freely and there are no obstructions in the cap or lid.
10	Is ultrasonic activity visible in nebulizer chamber?	Ultrasonic nebulizers use sound vibrations to create vapor droplets from liquid. This ultrasonic activity should be visible.
11	Ensure nebulizer chamber is properly aligned.	Verify mechanical connections are correct and secure. See BTA skills on Mechanical Attachments.
12	Ensure sufficient liquid in nebulizer chamber.	Add liquid to the chamber.
13	Loosen float in nebulizer chamber.	Ensure float system is loose and moves freely and there are no obstructions in the cap or lid.
14	Check cleanliness of air filter.	Air filters must be changed periodically when they become dirty. See BTA skills on Filters.
15	Is aerosol output zero?	Verify that some aerosol mist is produced.
16	Is aerosol output sufficient?	Clinical staff has complained of low aerosol (medicine) output even at maximum power.
17	Allow chamber liquid to de-aerate.	Wait for machine to de-aerate.
18	User warmer liquid.	Warm the liquid in use.
19	Wash nebulizer chamber.	Use water and diluted vinegar or alcohol. See BTA skills on Mechanical Cleaning.
20	Remove any blockages in tubing.	See BTA skills on Plumbing Blockages.
21	Check for contamination of nebulizer chamber.	Use water and diluted vinegar or alcohol. See BTA skills on Mechanical Cleaning.

22	Nebulizer is working properly.	Return the machine to service.

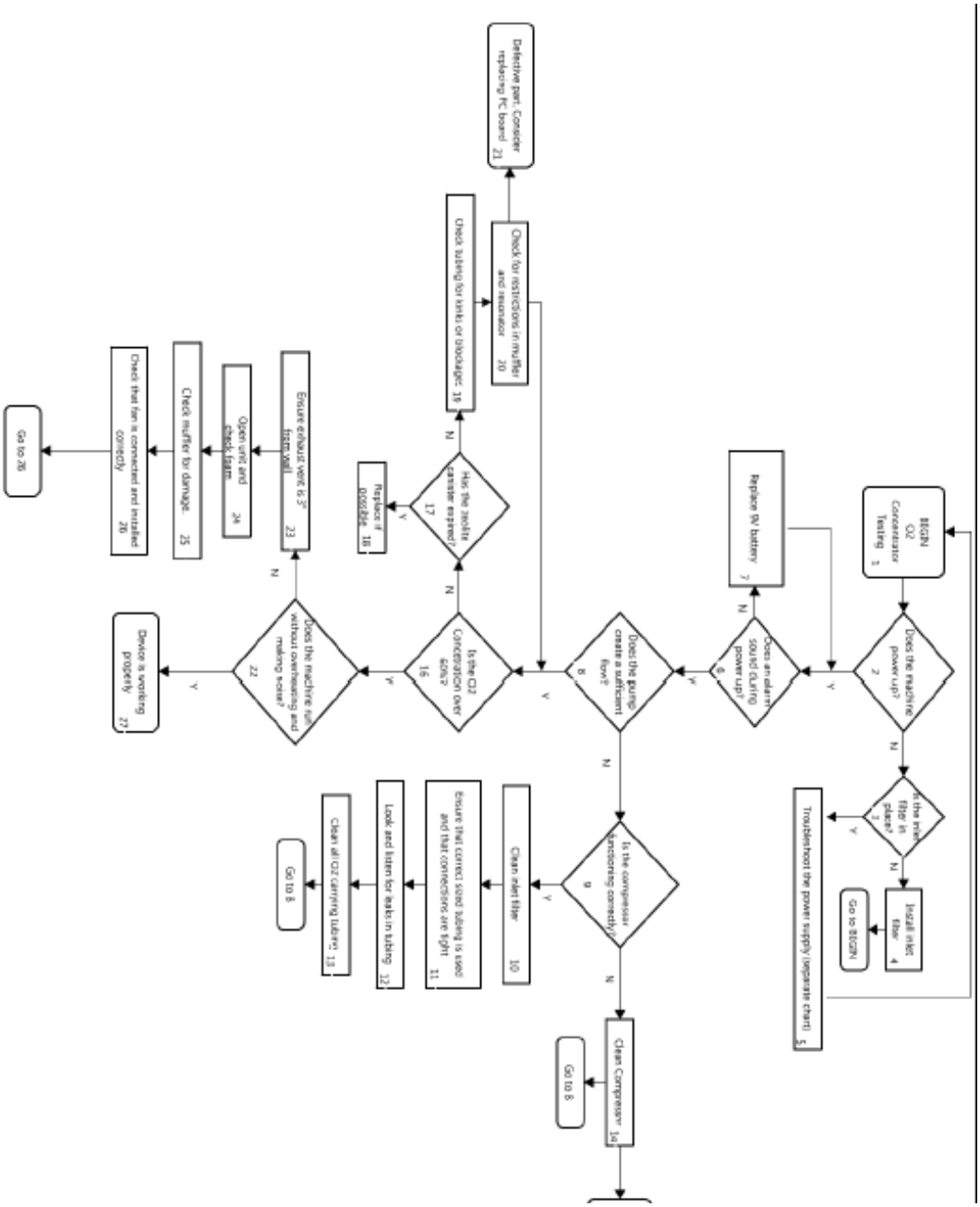
Preventative Maintenance

- Inspect exterior of equipment for damaged or missing hardware.
- Inspect the power cord, strain relief and plug/s for any signs of damage.
- Turn unit off, open user accessible covers and inspect unit for damage.
- Clean unit interior components and exterior with vacuum or compressed air.
- Inspect interior for signs of corrosion or missing hardware. Repair as required.
- Inspect electrical components for signs of excessive heat or deterioration.
- Inspect oxygen inlet orifice for restrictions.
- Inspect water jet assembly including orifice. Check for water leakage.
- Check gaskets and O-rings.
- Verify correct ultrasonic output for sharp water cone and misting.
- Verify correct operation of low-water cut-off circuit.
- Tune RF output if needed.
- Verify correct operation of all buttons, controls, displays and/or indicators.
- Verify correct operation of unit in all functional modalities.
- Clean exterior of unit including all accessories, cables, controls and displays.
- Clean air filter.
- Clean nebulizer chamber and lid daily or between each patient.
- Clean hoses and tubes daily.

Thoughts/ Comments/ Ideas

O2 Concentrator

Flowchart



Description

#	Text Box	Explanation
1	Begin O2 Concentrator Testing	Start the diagnostic process for a work order on O2 Concentrator.
2	Does the machine power up?	With unit plugged in, and power switch turned on, the display should light up and compressor should run, making noise.
3	Is the inlet filter in place?	Some models require the compressor inlet filter to be in place in order for machine to start. For all other models, proceed to step 5.
4	Install inlet filter	If available, install the foam inlet filter.
5	Troubleshoot the power supply (separate chart)	Use a multimeter at the leads of the compressor to ensure that sufficient voltage is reaching the machine. If insufficient, there may be a problem with the wiring or fuse. See flowchart on Power Supply and BTA skills on Power Supply.
6	Does the alarm sound during power up?	Both display lights and an audible alarm should sound after power switch is turned on.
7	Replace 9V battery	Unplug machine, ensure current battery has correct polarity, and replace with a new battery if necessary.
8	Does the pump create a sufficient flow?	Flow is identifiable by the floating ball in the flow meter and by bubbles in the humidifier. To check if there is sufficient flow, remove humidifier and place finger at air outlet. When outlet is covered, the ball should fall down. When outlet is unobstructed the ball should float. When flow rate is set to highest setting (5 liters per minute) the ball should be at its highest level in flow meter.
9	Is the compressor functioning correctly?	Check voltage into leads of compressor, and then check flow rate at exit. If the compressor is not producing max flow rate at sufficient voltage (120V), the compressor is not functioning correctly. (Proceed to 13)
10	Clean inlet filter	Foam inlet filter should be cleaned weekly by washing with soap and water. Ensure filter is dry before replacing. See BTA skills on Filters (Plumbing)
11	Ensure that correct sized tubing is used and that connections are tight.	Check that the diameter of all O2-carrying tubing matches the machine inlet diameters. Ensure that all connections are tight. Also ensure that the tubing being used cannot diffuse O2. See BTA skills on Connections (Plumbing)
12	Look and listen for leaks in tubing	While air is flowing, listen for sound of escaping O2 and run hand over tubing to feel stream. If holes exist, tube should be replaced, not patched. See BTA skills on Leaking (Plumbing)
13	Clean all O2-carrying tubing	Dirt or water droplets could block the airway. See BTA skills on Blockages (Plumbing)
14	Clean compressor	See BTA skills on cleaning/lubricating (Motors)
15	Defective Compressor: Consider replacing	If compressor is clean, and is still not producing correct flow rate it is probably faulty and needs to be replaced.
16	Is the O2 Concentration over 60%?	See BTA skills for Oxygen Concentration Measurement

		(Mechanical-Calibration)
17	Has the zeolite canister expired?	Zeolite canisters should be replaced every 25,000 hours. The granules start black and appear gray when they are no longer efficient for use.
18	Replace if possible	If available, replace expired zeolite canisters with new granules.
19	Check tubing for kinks or blockages	Ensure that all O2-carrying tubes are elongated and not twisted or bent. See BTA skills on Blockages (Plumbing)
20	Check for restrictions in muffler and resonator.	A restricted muffler would prevent waste gas from exiting the system freely. Disconnect the muffler and operate unit to see if this fixes concentration.
21	Defective part: Consider replacing PC board.	PC board could have tears or kinks that may be irrecoverable.
22	Does the machine run without overheating and making excessive noise?	The unit should not feel hot to the touch or make loud excessive noises.
23	Ensure exhaust vent is at least 3” from wall.	The exhaust pipe should be far enough away from external obstructions that the waste gas can flow freely into the atmosphere.
24	Open unit and check foam	Foam inside the machine degrades over time and can fall into compressor. Clean and replace foam if possible. See BTA skills on Cleaning (Mechanical)
25	Check muffler for damage	Ensure all tubing to muffler is intact and connected. Check muffler for cracks, damages. Consider replacing if broken.
26	Check that fan is connected and installed correctly	Ensure leads to fan are connected correctly. Check that fan is installed in correct direction of airflow.
27	Device is working properly.	With sufficient air flow and O2 concentration, the machine can be returned to service.

Preventive Maintenance

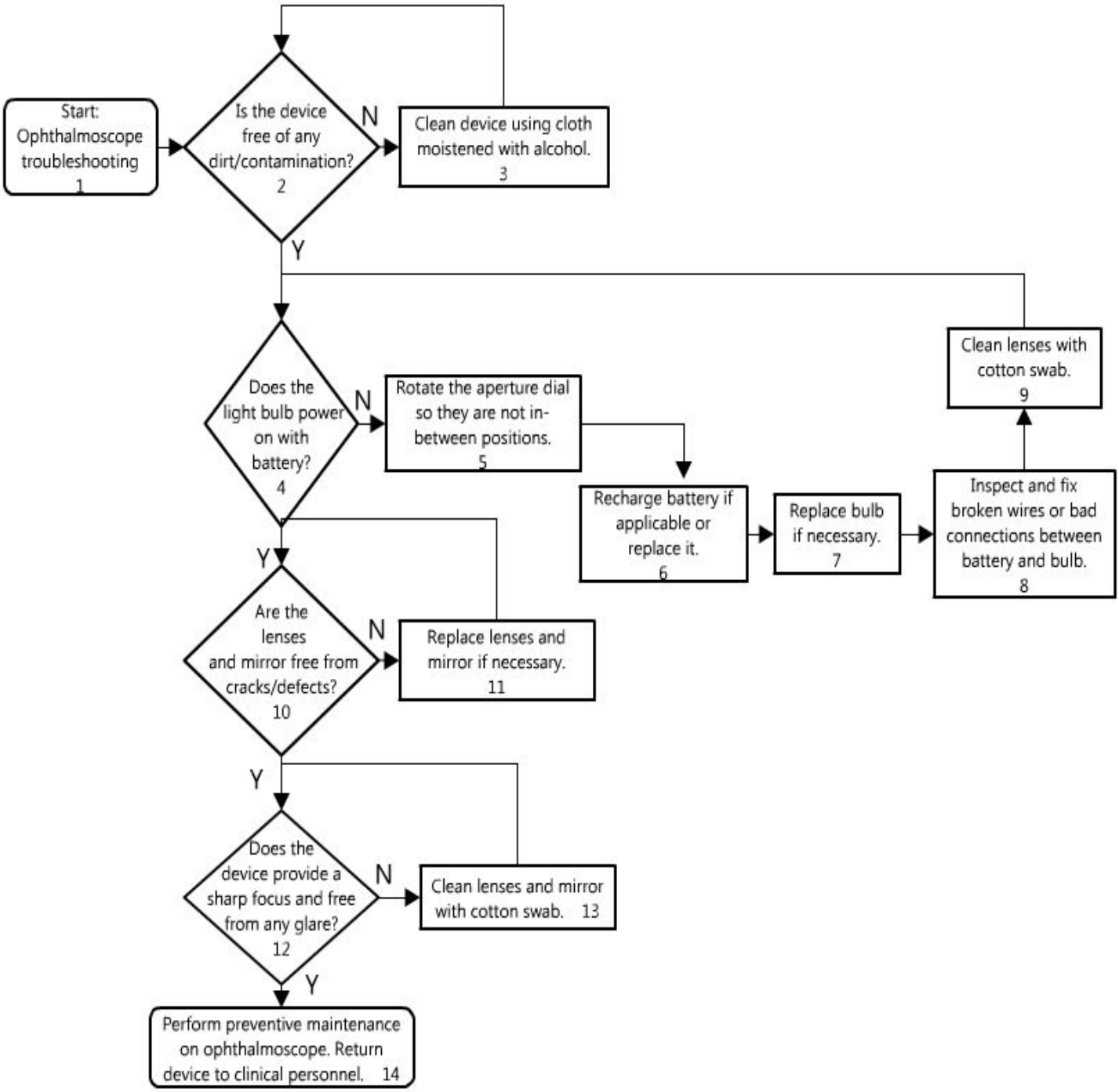
Always run machine for a few hours after maintenance before patient use

1. Clean humidifier and tubes
    a. Wash in warm soapy water, rinse thoroughly, and replace
2. Change distilled water
3. Remove and clean the foam air intake filter
    a. Wash with soap and water
    b. Ensure filter is dry *before* replacing but *do not* use heat to dry
4. Check Alarm system battery
    a. An audible alarm should sound when the machine is turned on
    b. Replace 9V battery when necessary
5. Check if Zeolite Canisters have expired (25,000 hours). The granules become grey when they are no longer effective.
6. Felt pre-filter should be changed once a month (if available)
7. Replace patient bacterial filter annually (if available)

Thoughts/ Comments/ Ideas

Ophthalmoscope

Flowchart



Description

#	Text Box	Comments
1	Start: Ophthalmoscope troubleshooting.	Begin diagnostic process for a work order for Ophthalmoscope.
2	Is the device free of any dirt/contamination?	Inspect ophthalmoscope for external cracks, damage and dirt.
3	Clean device using cloth moistened with alcohol.	Examine the device for dirt and contamination. See BTA skills on Mechanical Cleaning.
4	Does the light bulb power on with battery?	Power on the device with battery. Examine whether light bulb gives sufficient illumination.
5	Rotate the aperture dial so they are not in-between positions.	Aperture dial can be in-between positions.
6	Recharge battery if applicable or replace it.	Refer BTA skill set on Batteries to identify and replace damaged batteries.
7	Replace bulb if necessary.	Refer BTA skill set on Lighting/Indicators to replace non-functional light bulbs.
8	Inspect and fix broken wires or bad connections between battery and bulb.	Inspect wires and connections from battery to bulb using multimeter. Refer BTA skill set on Connections for identifying and fixing broken wires and bad connections.
9	Clean lenses with cotton swab.	Clean lenses to remove any dirt and contamination. See BTA skills on Mechanical Cleaning.
10	Are the lenses and mirror free from cracks/defects?	Any defect in the lenses and mirror will not provide a clear view.
11	Replace lenses and mirror if necessary.	Identify and replace with a suitable lens to get a clear view.
12	Does the device provide a sharp focus and free from any glare?	The lenses and mirror are dirty.
13	Clean lenses and mirror with cotton swab.	Clean lenses and mirror to remove any dirt and contamination.
14	Perform preventive maintenance on ophthalmoscope. Return device to clinical personnel.	Ophthalmoscope is working properly. Perform preventive maintenance before returning the device to clinical personnel.

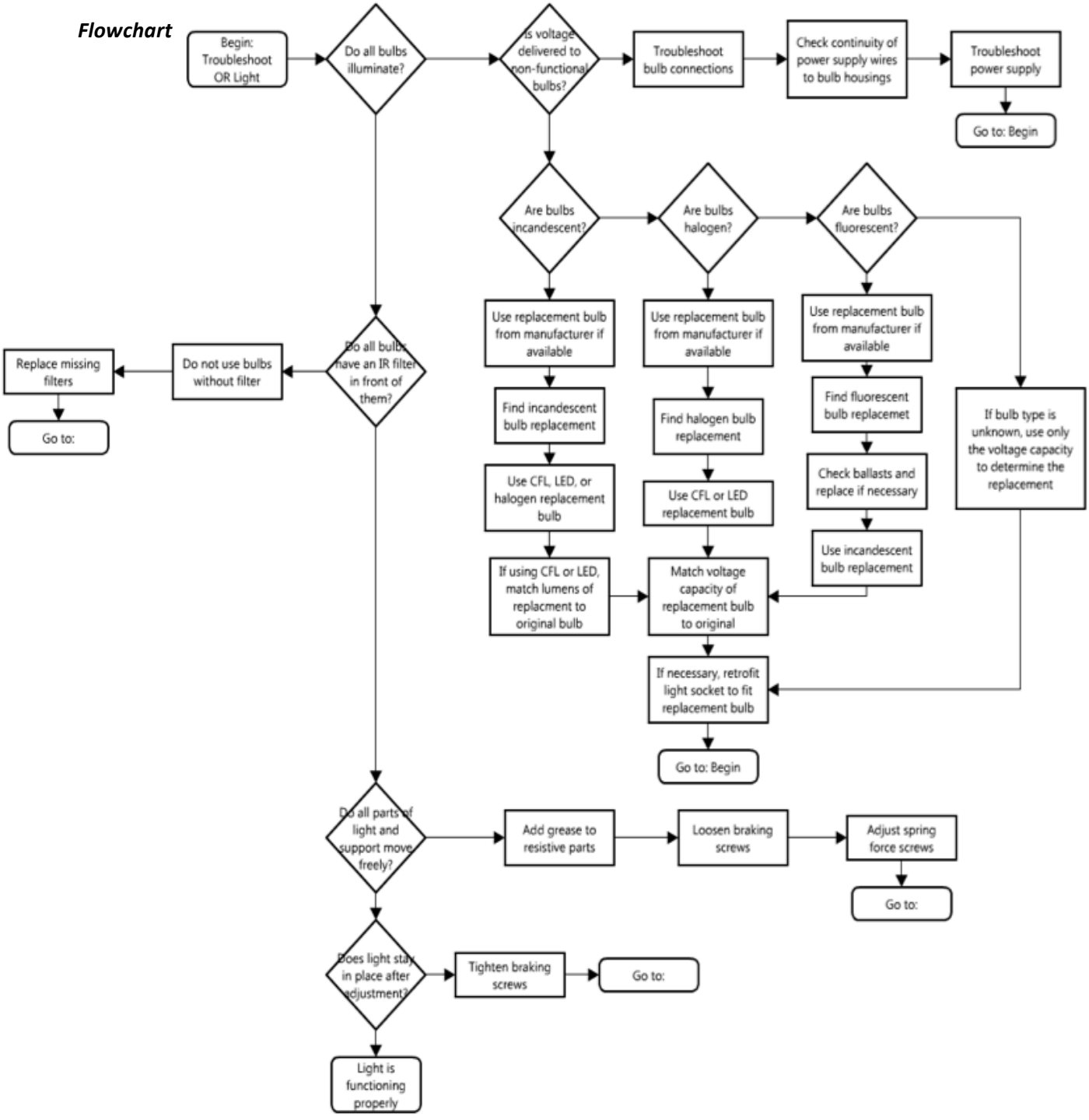
Preventative Maintenance

- Clean lenses and mirror components with ethanol solution or water, and soft cloth or cotton swab
- Regularly check battery and bulb for corrosion, and replace as needed
- Check for debris in rotating parts. Use a slender rigid object to prod dirt and debris free as needed
- Refocus device with each use

Thoughts/ Comments/ Ideas

OR LIGHT

Flowchart



Description

#	Text box	Explanation or Comment
1	Begin: Troubleshoot OR Light	Start the diagnostic process for a work order on an OR Light.
2	Do all bulbs illuminate?	Provide the light with power and observe whether or not all of the bulbs produce light.
3	Is voltage delivered to non-functional bulbs?	If some of the bulbs do not illuminate, it could be due to issues with the bulb or the power supply. Use a multimeter to check that appropriate voltage is being delivered to the bulb housings. See BTA skills on Electrical Lighting/Indicators.
4	Troubleshoot bulb connections	If bulbs do not illuminate and are not receiving power, then there may be something wrong with the connections from the bulb housing to the bulb itself. Inspect the housing, clean any residue on connections and mend poor connections.
5	Check continuity of power supply wires to bulb housings	Ensure that the bulb housings are connected to the power supply. Use a multimeter to check the continuity of the wires running from the power supply to the bulbs.
6	Troubleshoot power supply	If the device is connected to power but does not turn on, there is a problem with the power supply. This could be a problem with the wiring or connections within the device. See BTA skills on Power Supply.
7	Are bulbs incandescent?	Incandescent light bulbs use a tungsten filament encased inside a glass housing.
8	Are bulbs halogen?	Halogen bulbs have a tungsten filament encased inside a quartz housing. The housing is much closer to the filament than in incandescent light bulbs.
9	Are bulbs fluorescent?	Fluorescent bulbs have a sealed glass tube filled with mercury and an inert gas.
10	If bulb type is unknown, use only the voltage capacity to determine the replacement	Reference BTA skills: Unit: Lighting/Indicators, Skill: Fixtures.
11	Use replacement bulb from manufacturer if available	Acquire the bulb designed for the OR lamp unit by the same manufacturer as the unit. Use this replacement bulb to replace any

		broken bulbs in the lamp.
12	Find incandescent bulb replacement	Match the voltage capacity and wattage of replacement bulb to original.
13	Use CFL, LED, or halogen replacement bulb	If a CFL or LED bulb can be found that matches the voltage of the original incandescent bulb, then it may be used to replace the original bulb.
14	If using CFL or LED, match lumens of replacement to original bulb	If using a CFL or LED as a replacement, ensure that the lumens value of the replacement bulb matches that of the original.
15	Find halogen bulb replacement	Match the voltage capacity and wattage of replacement bulb to original.
16	Use CFL or LED replacement bulb	If a CFL or LED bulb can be found that matches the voltage of the original incandescent bulb, then it may be used to replace the original bulb.
17	Check ballasts and replace if necessary	Reference instruction document.
18	Find fluorescent bulb replacement	Match the voltage capacity and wattage of replacement bulb to original.
19	Check ballasts and replace if necessary	Reference instruction document.
20	Use incandescent bulb replacement	If an incandescent bulb can be found that matches the voltage of the original incandescent bulb, then it may be used to replace the original bulb.
21	Match voltage capacity of replacement bulb to original	If the bulb type of the original is unknown, then the voltage capacity alone may be used to find a replacement. Match this value of the replacement bulb to that of the original.
22	If necessary retrofit light socket to fit replacement bulb	Reference BTA skills: Unit: Lighting/Indicators, Skill: Fixtures.
23	Go to: Begin	Go back to step 1 to restart the troubleshooting process.
24	Do all bulb have an IR filter in front of them?	Check that all of the functional bulbs have infrared filters between the bulb and the operating field. This filter usually looks like a plastic sheet

		sitting in front of the bulb in its housing.
25	Do not use bulbs without filter	DO NOT use the lamp if any illuminating bulbs do not have a filter. This filter is necessary to ensure the safety of patients.
26	Replace missing filters	Insert infrared filters wherever missing. These filters can be taken from bulb housings containing non-functional bulbs or from other OR lamp units. DO NOT handle filters with bare hands.
27	Go to:	
28	Do all parts of light and support move freely?	Manipulate the lamp to ensure that all moving parts can be easily adjusted.
29	Add grease to resistive parts	If any moving parts of the lamp resist adjustment, lubricate these parts using grease or oil.
30	Loosen braking screws	Locate the braking screws on the lamp unit. Loosen these screws to allow for more fluid movement.
31	Adjust spring force screws	Locate and adjust the tightness of spring force screws on the lamp unit to change the amount of tension in the lamp supports.
32	Go to:	
33	Does light stay in place after adjustment?	Ensure that the lamp stays in place after it has been adjusted. Try several manipulations of the lamp and let lamp stand in each for a few minutes. Observe any deviations from the original adjustment.
34	Tighten braking screws	If lamp moves after adjustment, tighten the braking screws to prevent this movement.
35	Go to:	
36	Light is functioning properly	

***Preventative* Maintenance:**

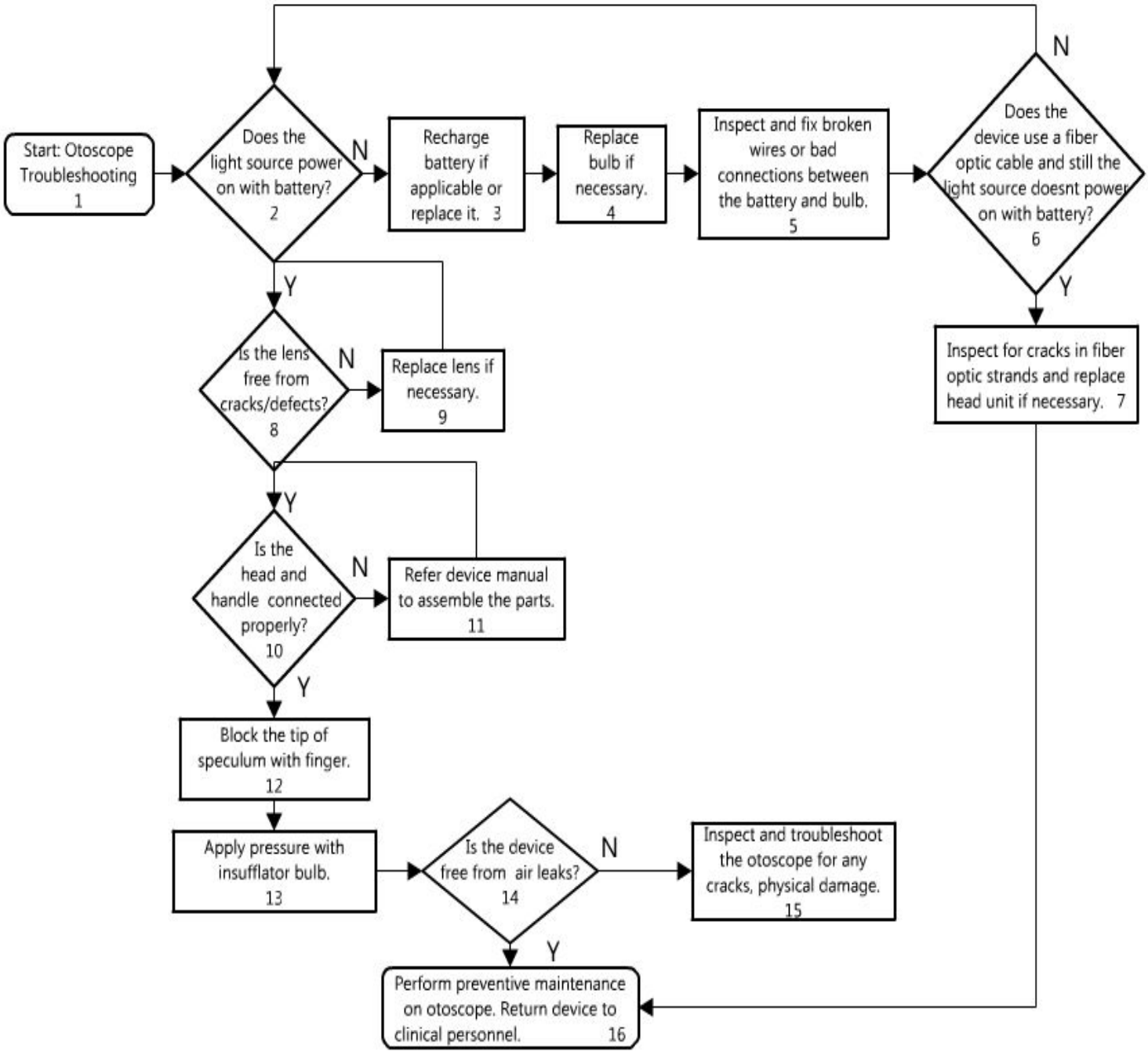
- Checking mechanical functionality (grease, tightening, etc.),
    - Check supporting framework for mobility
    - If framework is high resistive to movement, grease resistive parts and/or loosen braking screws

    - If framework moves too easily (does not stay in place after adjustment), tighten braking screws
- Cleaning bulb housings
    - Clean the bulb housings periodically so lengthen bulb life and improve light quality
    - Do not touch IR filters with bare hands
    - Fingerprints left on bulbs/filters will cause overheating and could damage lamp
- Keep any bulbs that could be viable replacements available
    - Salvage functional light bulbs from non-functional OR lamps and keep for future use as replacements in other lamps
    - Keep any bulbs that are viable replacements for those in lamp to use as replacements when needed

Thoughts/Comments/Concerns

Otoscope

Flowchart



Description

#	Text Box	Comments
1	Start: Otoscope Troubleshooting	Begin diagnostic process for a work order on Otoscope.
2	Does the light source power on with battery?	Power on the device with battery. Examine whether light bulb gives sufficient illumination.
3	Recharge battery if applicable or replace it.	Refer BTA skill set on Batteries to identify and replace damaged batteries.
4	Replace bulb if necessary.	Refer BTA skill set on Lighting/Indicators to replace non-functional light bulbs.
5	Inspect and fix broken wires or bad connections between the battery and bulb.	Inspect wires and connections from battery to bulb using multimeter. Refer BTA skill set on Connections for identifying and fixing broken wires and bad connections.
6	Does the device use a fiber optic cable and still the light source doesn't power on with battery?	There are two types of otoscopes: • Conventional otoscope • Fiber optic otoscope If the bulb still doesn't power on then there might be cracks in the fiber optic strands. So the unit might have to be replaced.
7	Inspect for cracks in fiber optic strands and replace the unit if necessary.	If the illumination is not sufficient then inspect for cracks in fiber optic strands.
8	Is the lens free from cracks/defects?	Any defect in the eyepiece lens obstructs vision of ear canal.
9	Replace lens if necessary.	Identify and replace with a suitable lens.
10	Is the head and handle connected properly?	Improper connection between head and handle may result in faulty operation of the device.
11	Refer device manual to assemble the parts.	Follow instructions in the device manual to assemble the parts together.
12	Block the tip of speculum with finger.	This test is performed to detect any air leaks in the device. Connect the pressure bulb to the connector in otoscope to perform this test.
13	Apply pressure with insufflator bulb.	Apply pressure continuously over a period of time and check whether it can be felt at the tip of speculum.
14	Is the device free from air leaks?	If the flow of air due to pressure is not felt at the tip of speculum then there is a possible air leak in the device.
15	Inspect and troubleshoot the otoscope for any cracks, physical damage.	Inspect otoscope for external cracks, damage, or dirt.
16	Perform preventive maintenance on Otoscope. Return device to clinical personnel.	Otoscope is working properly. Perform preventive maintenance before returning the device to clinical personnel.

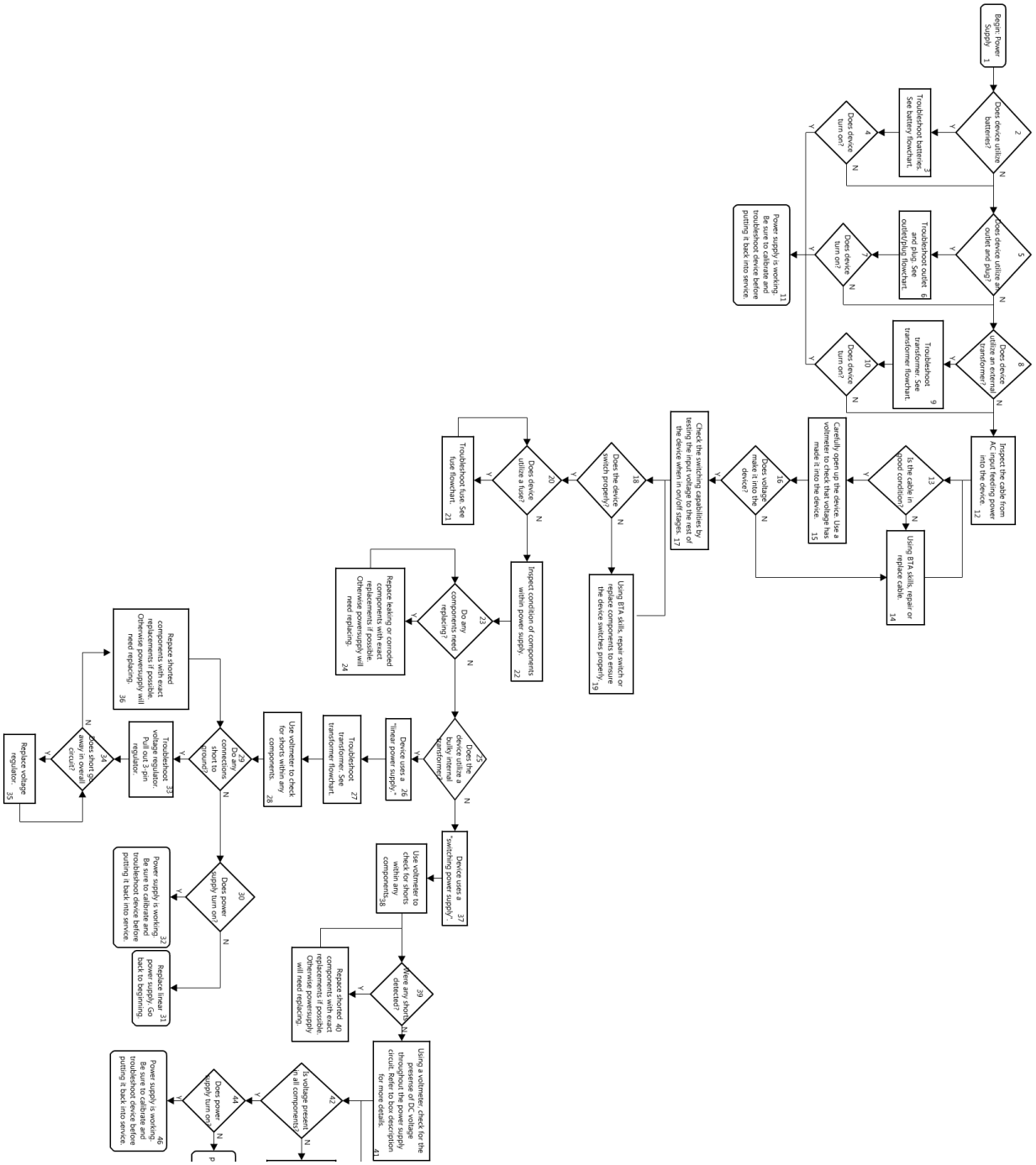
Preventative Maintenance

- Ensure use of proper tips that are clean and free of defects
- Make sure tips are connected tightly for each use
- Regularly recharge or replace battery, as needed
- Clean lenses with soft cloth or cotton swab, and water or ethanol solution
- Remove debris from any rotating parts, use a thin, rigid member if necessary
- If using hand pump, ensure connections are tight and tubing is free of defects

Thoughts/ Comments/ Ideas

Power Supply (Overall)

Flowchart



Description

#	Text Box	Comments
1	Begin: Power Supply	Begin diagnostic process for a work order on Power Supply. Testing and maintenance is advised when a device fails to turn on.
2	Does device utilize batteries?	A device may run on primary or chargeable batteries. This can be in addition to a wall input.
3	Troubleshoot batteries. See battery flowchart.	Refer to the battery troubleshooting guide to ensure the proper functionality of the device batteries.
4	Does device turn on?	If after successfully troubleshooting the batteries, the device power supply problem may resolve.
5	Does device utilize an outlet and plug?	A device may run on the AC voltage input from wall sockets.
6	Troubleshoot outlet and plug. See outlet/plug flowchart.	Refer to the output/plug troubleshooting guide to ensure the proper functionality of the device's input power.
7	Does device turn on?	If after successfully troubleshooting the outlet and plug, the device power supply problem may resolve.
8	Does device utilize an external transformer?	A device may require that the AC wall input is transformed into the appropriate voltage for device functioning.
9	Troubleshoot transformer. See transformer flowchart.	Refer to the transformer troubleshooting guide to ensure the proper functionality of the device's transformer.
10	Does device turn on?	If after successfully troubleshooting the transformer, the device power supply problem may resolve.
11	Power supply is working. Be sure to calibrate and troubleshoot device before putting it back into service.	Be sure to troubleshoot, calibrate, and appropriately test medical device before releasing to clinician.
12	Inspect the cable from AC input feeding power into the device.	Notice any deformities or exposed wires in power cord.
13	Is the cable in good condition?	If any deformities or exposed wires are found, the cable is not in good condition.
14	Using BTA skills, repair or replace cable.	Cable can be resoldered, taped, and assembled such that the cable is functional and safe. Replace it if these methods are not adequate.
15	Carefully open up the device. Use a voltmeter to check that voltage has made it into the device.	Follow the power cord into the device. Immediately check the voltage at the point where the cord does not pass through any circuit components.
16	Does voltage make it into the device?	Voltage may not properly conduct through a poorly conducting cable.
17	Check the switching capabilities by testing the input voltage to the rest of the device when in on/off stages.	Using voltmeter to measure voltages in on and off states of the device's power switch.
18	Device should yield the appropriate voltage when switched on and no voltage when switched off.	When turned on and connected, the voltage should conduct. When device is switched off, there should be an open current in which no electrical conduction occurs.
19	Does the device switch properly?	If voltage conducts when switch is on, and fails to conduct when switch is off, the device switches properly.
20	Using BTA skills, repair switch or replace components to ensure the device switches properly.	Mechanical switches require simple observation and repair. An electrical transducer and/or relay will require the engineer uses the voltmeter to determine if an open circuits are occurring in any of the circuit components. These parts will have to be replaced as necessary. See BTA skills on Mechanical Switches and Electrical

		Simple.
21	Does device utilize a fuse?	Use a mulitmeter to assess whether or not the fuse shorts. A shortage indicates a functioning fuse.
22	Troubleshoot fuse. See fuse flowchart.	If the fuse shorts, it is still functioning.
23	Inspect condition of components within power supply.	Are any capacitors puffy? Are any components melted or burnt? Are there any signs of rust or corrosion? These obvious faults should clearly indicate any problem within the power supply.
24	Do any components need replacing?	If any components are not found to be in good condition, they will need to be replaced exactly. This may not always be possible, and harvesting components from old, dysfunctional equipment is always a safe bet.
25	Replace leaking or corroded components with exact replacements if possible. Otherwise power supply will need replacing.	The determined components should be removed and replaced using solder and a soldering iron. If exact or equivalent replacements cannot be made, the power supply will need replacing.
26	Does the device utilize a bulky internal transformer?	After opening the device, and large transformer with input and output specification should be obvious in a linear power supply.
27	Device uses a “linear power supply.”	Linear power supplies are characteristic of bulky and large devices. These power supplies use a transformer, rectifier, regulator, and filter in series to achieve the desired and necessary voltage signal for the device.
28	Troubleshoot transformer. See transformer flowchart.	Refer to the transformer troubleshooting guide to ensure the proper functionality of the device’s transformer.
29	Use voltmeter to check for shorts within any components.	Using the connection mode on the voltmeter, methodically move through each component of the power supply to determine if there are any shorts to ground.
30	Do any connections short to ground?	It should be clear if a component is not conducting properly by assessing with a multimeter.
31	Power supply is working. Be sure to calibrate and troubleshoot device before putting it back into service.	Be sure to troubleshoot, calibrate, and appropriately test medical device before releasing to clinician.
32	Troubleshoot voltage regulator. Pull out 3-pin regulator.	Voltage regulator handles large spikes in voltages. Pull out the 3-pin to determine if the regulator has failed.
33	Does short go away in overall circuit?	Using the connection mode on the voltmeter, methodically move through each component of the power supply to determine if there are any shorts to ground.
34	Replace voltage regulator.	If the circuit does not short when voltage regulator is removed, the voltage regulator needs replacing.
35	Replace shorted components with exact replacements if possible. Otherwise power supply will need replacing.	The determined components should be removed and replaced using solder and a soldering iron. If exact or equivalent replacements cannot be made, the power supply will need replacing.
36	Device uses a “switching power supply.”	Switching power supplies are characteristically lighter than linear power supplies. They also use a transformer, but less bulky ones. They fit amount the other smaller circuit components.
37	Use voltmeter to check for shorts within any components.	Using the connection mode on the voltmeter, methodically move through each component of the power supply to determine if there are any shorts to ground.
38	Were any shorts detected?	It should be clear if a component is not conducting properly by

		assessing with a multimeter.
39	Replace shorted components with exact replacements if possible. Otherwise power supply will need replacing.	The determined components should be removed and replaced using solder and a soldering iron. If exact or equivalent replacements cannot be made, the power supply will need replacing.
40	Using a voltmeter, check for the presence of DC voltage after rectification and before the small internal transformer.	Using the voltage mode on the voltmeter, methodically move through each component of the power supply to determine if there the appropriate DC voltage is being conducted.
41	Troubleshoot internal transformer. It's important that the input and output is of the appropriate voltage.	Refer to the transformer troubleshooting guide to ensure the proper functionality of the device's transformer. If the internal transformer in a switching power supply is not functioning, it will need to be replaced.
42	Using a voltmeter, check for the presence of DC voltage after rectification after the transformer.	Using the voltage mode on the voltmeter, methodically move through each component of the power supply to determine if there the appropriate DC voltage is being conducted.
43	Is voltage present in all components?	It should be clear if a component is not conducting properly by assessing with a voltmeter.
44	Replace any non-function components with exact replacements if possible. Otherwise power supply will need replacing.	The determined components should be removed and replaced using solder and a soldering iron. If exact or equivalent replacements cannot be made, the power supply will need replacing.
45	Power supply is working. Be sure to calibrate and troubleshoot device before putting it back into service.	Be sure to troubleshoot, calibrate, and appropriately test medical device before releasing to clinician.

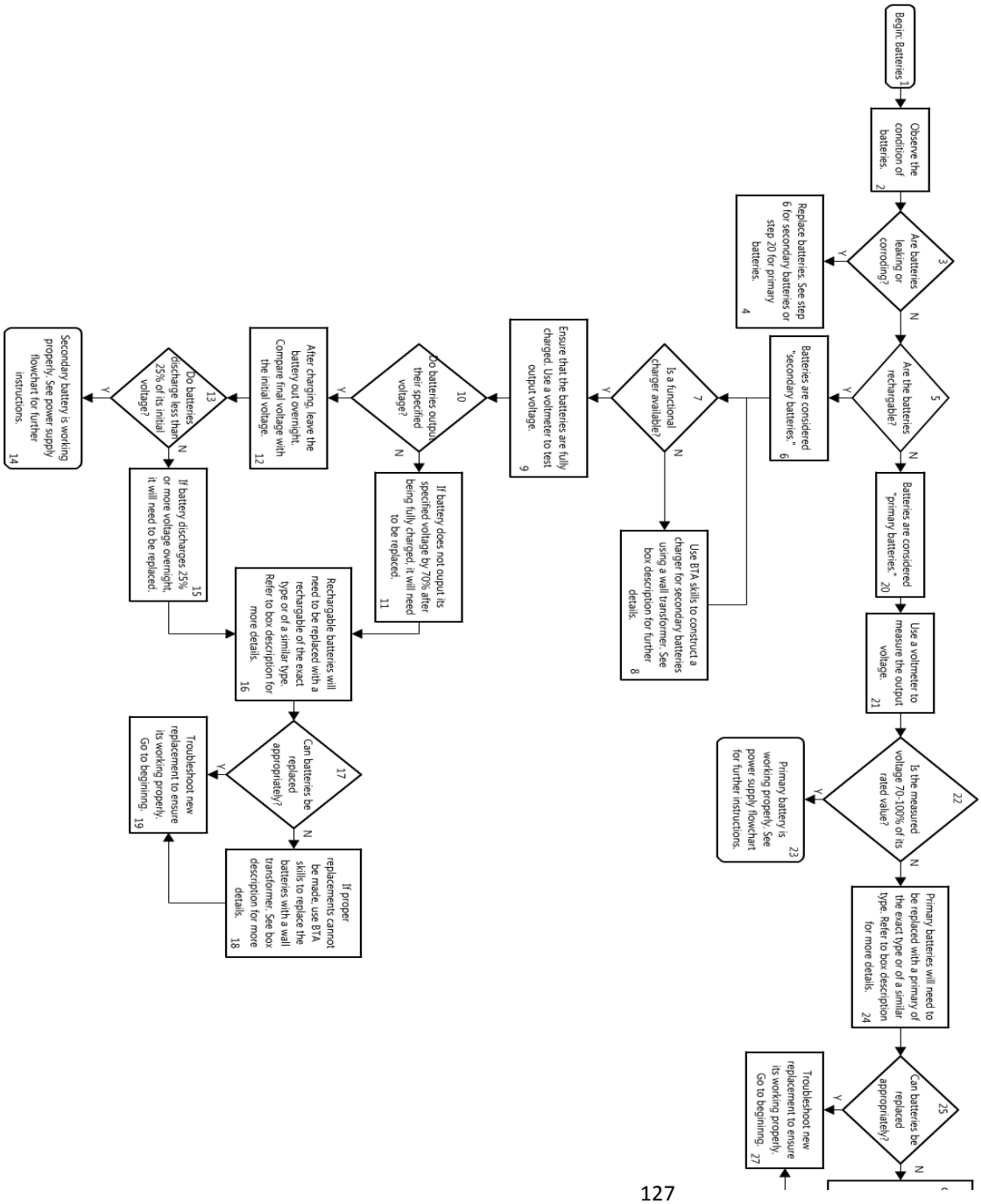
Preventive Maintenance

- Clean device clean. Avoid using water to do so.
- Store in a dry place with no possibility of contact with water.
- Store within the range of -40-55°C
- If device is not used frequently, unplug from wall input to prevent possibilities of voltage spikes. Regulators often malfunction after high voltage inputs, and keeping it unplugged reduces the risk.

Thoughts/ Comments/ Ideas

Power Supply (Battery)

Flowchart



Description

#	Text Box	Comments
1	Begin: Batteries	Begin diagnostic process for a work order for Batteries. Testing and maintenance is advised when a device using batteries fails to turn on.
2	Observe the condition of batteries.	Are there any signs of leaking, rust, corrosion? These obvious faults should clearly indicate any problems within batteries.
3	Are batteries leaking or corroding?	If any batteries are not found to be in good condition, they should be discarded and replaced.
4	Replace batteries. See step 6 for secondary batteries or step 20 for primary batteries.	The identified problematic batteries should be discarded and replaced following the guidelines for their type.
5	Are the batteries rechargeable?	NiCd, Lead Acid, NiMH, Li-ion batteries are common chargeable batteries. Lithium or carbon-zinc are not rechargeable.
6	Batteries are considered “secondary batteries.”	Secondary batteries have the ability to be recharged.
7	Is a functional charger available?	Chargers typically accompany types of rechargeable batteries.
8	Use BTA skills to construct a charger for secondary batteries using a wall transformer. See box description for further details.	If no charger is available, use BTA skills to construct an appropriate charger. BTA protocol states that this can be done using a wall transformer with a female coaxial cable connector. Transformer must match the input voltage (110 vs. 240 V), the output voltage, voltage type (AC/DC), and the output current capacity of the batteries. If the original charger is not available, connections to the batteries can be made by opening the device and wiring in new connections. Alligator clips should suffice.
9	Ensure that the batteries are fully charged. Use a voltmeter to test output voltage.	Fully charge batteries before assessing their ability to hold their charge over time.
10	Do batteries output their specified voltage?	Measure and note the initial voltage before leaving them to sit overnight.
11	If battery does not output its specified voltage by 70% after being fully charged, it will need to be replaced.	If this initial voltage is not at least 70% of its rated value at full charge, it is not acceptable and should be replaced.
12	After charging, leave the battery out overnight. Compare final voltage with the initial voltage.	Let the battery sit overnight (connected to nothing) to assess its ability to hold a charge over time.
13	Do batteries discharge less than 25% of its initial voltage?	If more than 75% of charge is maintained, the battery is suitable for use.
14	Secondary battery is working properly. See power supply flowchart for further instructions.	Move on to the next step of the power supply flowchart if device still does not turn on. Be sure to troubleshoot, calibrate, and appropriately test medical device before releasing to clinician.
15	If battery discharges 25% or more voltage overnight, it will need to be replaced.	If less than 75% of charge is maintained, the battery is not suitable for use and will need to be placed.
16	Rechargeable batteries will need to be replaced with a rechargeable of the exact type or of a similar type. Refer to box description for more details.	Replacements should be an exact match with type, voltage, and capacity. An imperfect match is permitted if substituting with a primary battery of a larger capacity with same type and voltage.

17	Can batteries be replaced appropriately?	Exact replacements may not be realistic or available.
18	If proper replacements cannot be made, use BTA skills to replace the batteries with a wall transformer. See box description for more details.	Here are some additional suitable substitutions: -NiCd for NiMH of the same voltage and capacity – matching voltage takes priority -NiMH for NiCd of the same voltage and capacity – matching voltage takes priority The only downside is that NiCd have lower capacities and operate for shorter periods of time before needing to be charged.
19	Troubleshoot new replacement to ensure it's working properly. Go to beginning.	Once an appropriate replacement or substitution has bee made, troubleshoot device with new battery solution.
20	Batteries are considered "primary batteries."	Primary batteries are not reusable and cannot be recharged.
21	Use a voltmeter to measure the output voltage.	Check the output of the primary batteries as is.
22	Is the measured voltage 70-100% of its rated value?	If voltage is less than 70% of its rated value, it must be discarded and replaced.
23	Primary battery is working properly. See power supply flowchart for further instructions.	Move on to the next step of the power supply flowchart if device still does not turn on. Be sure to troubleshoot, calibrate, and appropriately test medical device before releasing to clinician.
24	Primary batteries will need to be replaced with a primary of the exact type or of a similar type. Refer to box description for more detail.	Replacements should be an exact match with type, voltage, and capacity. An imperfect match is permitted if substituting with a primary battery of a larger capacity with same type and voltage.
25	Can batteries be replaced appropriately?	Exact replacements may not be realistic or available.
26	If proper replacements cannot be made, use BTA skills to replace the batteries with a constructed "battery pack" in series or in parallel. See box description for more details.	Create a battery pack by adding primary batteries in series or in parallel to achieve the same total voltage and/or capacity ratings. -In parallel: Maintains voltage, Adds Capacities -In series: Adds voltages, Maintains Capacities
27	Troubleshoot new replacement to ensure it's working properly. go to beginning.	Once an appropriate replacement or substitution has bee made, troubleshoot device with new battery solution.

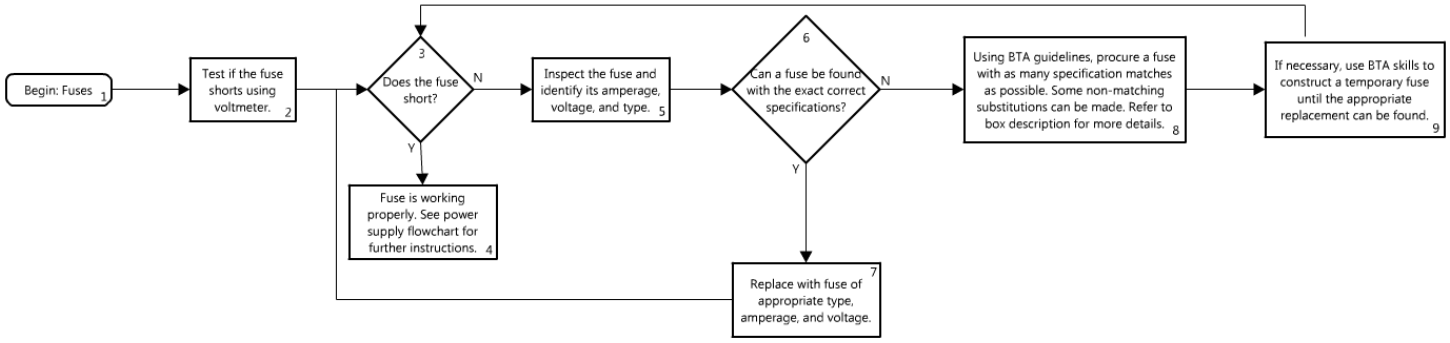
Preventive Maintenance

- Regularly (ideally every 6 months) check for faults, leaking, and corrosion.
- Do not store in extreme temperatures.
- When using an alternative source of power in the device, remove the batteries.
- For secondary batteries:
    - Do not let batteries discharge past their lower voltage limit
    - Check devices with secondary batteries every 6 months and perform discharge overnight test.

Thoughts/ Comments/ Ideas

Power Supply (Fuse)

Flowchart



Description

#	Text box	Explanation or Comment
1	Begin: Fuses	Begin diagnostic process for a work order on Fuses. Testing and maintenance is advised with any device using a fuse.
2	Test if the fuse shorts using voltmeter.	Use a voltmeter to assess whether or not the fuse shorts (working).
3	Does the fuse short?	If the fuse shorts, the transformer must not be functioning.
4	Fuse is working properly. See power supply flowchart for instructions.	Move on to the next step of the power supply flowchart if device still does not turn on. Always check with clinician before putting a device back into clinical use.
5	Inspect the fuse and identify its amperage, voltage, and type.	Typically the amperage, voltage, and type is printed on the fuse or device that requires it. If not, make an educated guess by comparing with fuses of known specifications. Additionally, use the knowledge of the device to estimate which fuse is best.
6	Can a fuse be found with the exact correct specifications?	Exact specification matches may not be possible or realistic.
7	Replace the fuse of appropriate type, amperage, and voltage.	Simply remove and replace new fuse match.
8	Using BTA guidelines, procure a fuse with as many specification matches as possible. Some non-matching substitutions can be made. Refer to box description for more details.	1. Amperage: Replace with lower amperage - will need to be replaced more frequently. **Do not replace with higher amperage**. 2. Voltage: A higher voltage can replace a lower voltage fuse; **a lower voltage fuse cannot replace a higher voltage fuse**. 3. Type: Fast acting fuse can replace a slow acting fuse (it will need to be replaced more frequently). **Slow acting cannot replace fast acting**.
9	If necessary, use BTA skills to construct a temporary fuse until the replacement can be found.	Obtain a suitable fuse that matches as many specifications as possible.

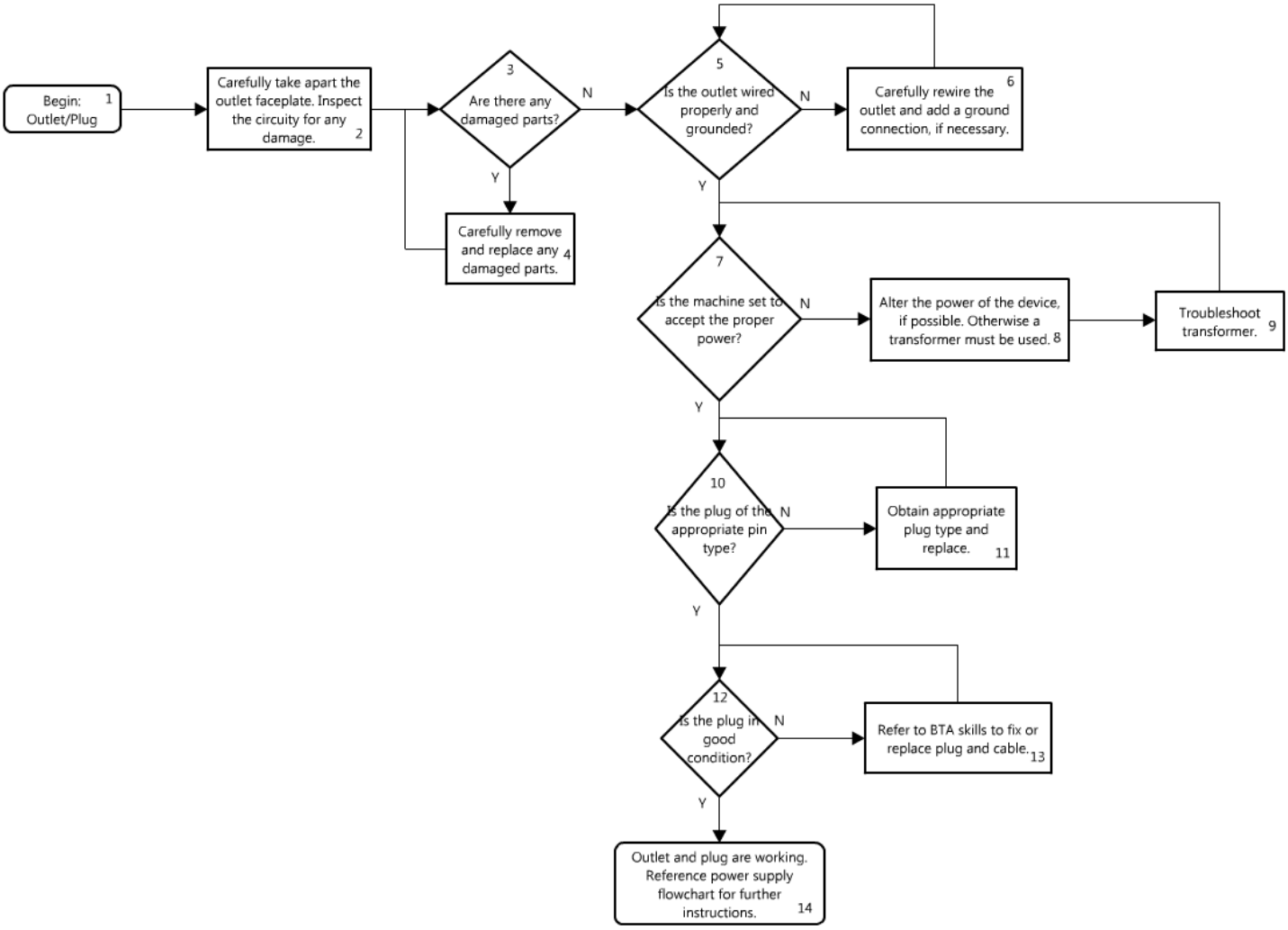
Preventive Maintenance

- Best to keep a stock of frequently use fuses in the workshop.

Thoughts/ Comments/ Ideas

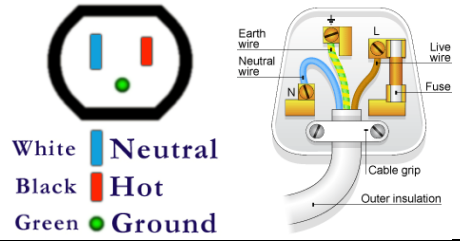
Power Supply (Outlet Plug)

Flowchart



Warning: Handling Electrical Equipment is dangerous. Please wear insulated gloves and use insulated equipment whenever handling high voltage outputs.

Description

#	Text Box	Comments
1	Begin: Outlet/Plug	Begin diagnostic process for a work order on Outlet/Plug. Testing and maintenance is advised when a device that uses a wall input fails to turn on.
2	Carefully take apart the outlet faceplate. Inspect the circuitry for any damage.	Using BTA skills for Power Supply, carefully take off the outlet faceplate. Disconnecting the main power while dismantling is advised.
3	Are there any damaged parts?	Inspect components. Is anything disconnected? Is anything clearly burned or melted?
4	Carefully remove and replace any damaged parts.	Remove, replace, or reconnect any non-functioning parts.
5	Is the outlet wired properly and grounded?	Using BTA guidelines, use a voltmeter to check for the output voltage and current. Are the live, neutral, and ground wires appropriate? What about in the device plug? 
6	Carefully rewire the outlet and add a ground connection, if necessary.	Use BTA skills to carefully rewire anything improperly wired. Disconnect the main power!
7	Is the machine set to accept the proper power?	Check the machine specifications. Does the device accept the appropriate wall power?
8	Alter the power of the device if possible; otherwise use transformer	Some devices allow the input power to be altered. Otherwise obtain the transformer of the appropriate input and output voltages.
9	Troubleshoot transformer.	See the transformer troubleshooting flowchart to ensure the new transformer is working properly.
10	Is the plug of the appropriate pin type?	Does the plug pin configuration fit into the wall socket?
11	Obtain appropriate plug type and replace.	Obtain a replacement and utilize BTA skills to replace. Otherwise obtain a pin type adapter. Just ensure the machine is of the appropriate power, as pin type is indicative of power accepted.
12	Is the plug in good condition?	Pins shouldn't wiggle, be bent or rusted.
13	Refer to BTA skills to fix or replace plug and cable.	Tighten pins that wiggle. Straighten any bent pins with pliers. Remove any rust with sandpaper.
14	Outlet and plug are working. Reference power supply flowchart for further instructions.	Move on to the next step of the power supply flowchart if device still does not turn on. Always check with clinician before putting a piece of equipment back into use.

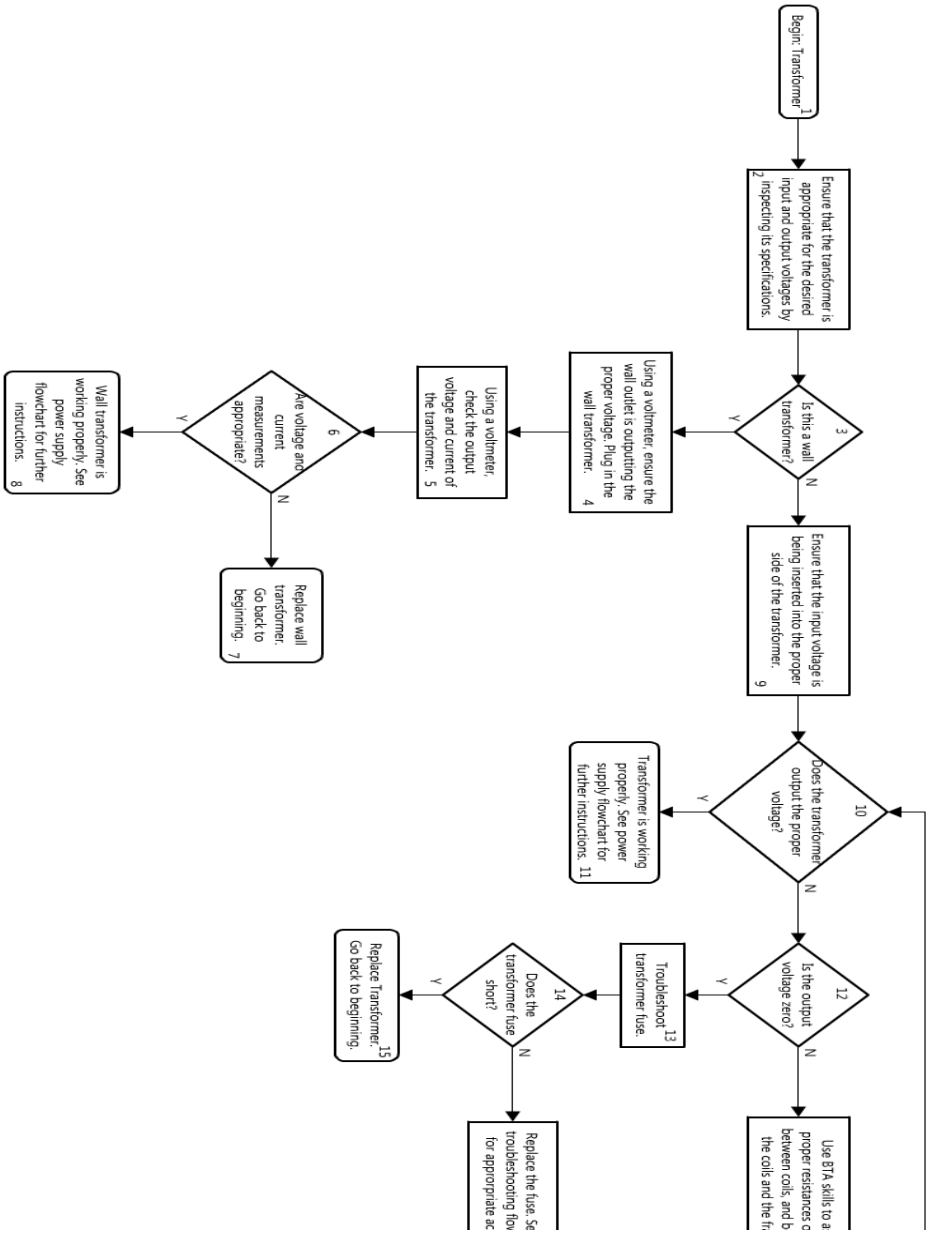
Preventive Maintenance

- Verify electrical outlets are wired properly and grounded on a regular basis, at least annually.
- Insert and remove wires carefully. When removing, pull on the plug, not the cable.
- Avoid exhibiting cables to sharp bends.
- Use electrical tape to contain fraying wires.

Thoughts/ Comments/ Ideas

Power Supply (Transformer)

Flowchart



Description

#	Text Box	Comments
1	Begin: Transformer	Begin diagnostic process for a work order on Transformer. Testing and maintenance is advised when a device using a transformer fails to turn on.
2	Ensure that the transformer is appropriate for the desired input and output voltages by inspecting its specifications.	Transformers typically print the required input and desired output voltages on its surface. It is necessary to adhere to these requirements for safety and appropriate transformer performance.
3	Is this a wall transformer?	A wall transformer converts AC input voltage to a DC output. It is also known as an “AC/DC adapter.”
4	Using a voltmeter, ensure the wall outlet is outputting the proper voltage. Plug in the wall transformer.	As a precaution, it is always good to ensure that the input to the transformer is of the correct voltage before plugging it in.
5	Using a voltmeter, check the output voltage and current of the transformer.	After plugging in the transformer, place one probe from the voltmeter on the interior DC output connector, and one on the exterior of the connector. 
6	Are voltage and current measurements appropriate?	After checking, ensure that these measurements match the wall transformer’s specifications.
7	Replace wall transformer. Go back to beginning.	If accurate voltage and current outputs are not obtained, replace the wall transformer.
8	Wall transformer is working properly. See power supply flowchart for further instructions.	Move on to the next step of the power supply flowchart if device still does not turn on. Always check with clinician before putting a piece of equipment back into use.
9	Ensure that the input voltage is being inserted into the proper side of the transformer.	It is absolutely necessary for the input voltage to enter the correct side of the transformer for safety and appropriate transformer performance.
10	Does the transformer output the proper voltage?	Using a voltmeter, check the output voltage. Ensure that these measurements match the transformer’s specifications.
11	Transformer is working properly. See power supply flowchart for further instructions.	Move on to the next step of the power supply flowchart if device still does not turn on. Always check with clinician before putting transformer back into clinical use.
12	Is the output voltage zero?	If the voltage is zero, absolutely no potential is being emitted from the transformer. This is indication of further damage.
13	Troubleshoot transformer fuse.	Use a voltmeter to assess whether or not the fuse shorts. A shortage indicates a functioning fuse.
14	Does the transformer fuse short?	If the fuse shorts, it is still functioning and the transformer is not functioning.
15	Replace Transformer. Go back to the beginning.	If the voltage is zero and the fuse is working properly, the transformer is should not be repaired.
16	Replace the fuse. See fuse troubleshooting flow chart for appropriate actions.	Refer to the fuse troubleshooting guide to appropriately replace the transformer fuse.
17	Go back to beginning.	Troubleshoot entire transformer when fuse has been replaced.

18	Use BTA skills to assess proper resistances of coils, between coils, and between the coils and the frames.	If the voltage is not zero, but also not the appropriate voltage, use the BTA skills to assess the resistances within the transformer to determine which parts may need to be recoiled. Complete this step only if recoiling is possible. Otherwise, the transformer will need replacing.
19	Rewind transformer if possible and necessary. Otherwise replace transformer.	If resistances indicate that the transformer needs recoiling, rewind if coils are exposed. Otherwise, the transformer will need replacing.

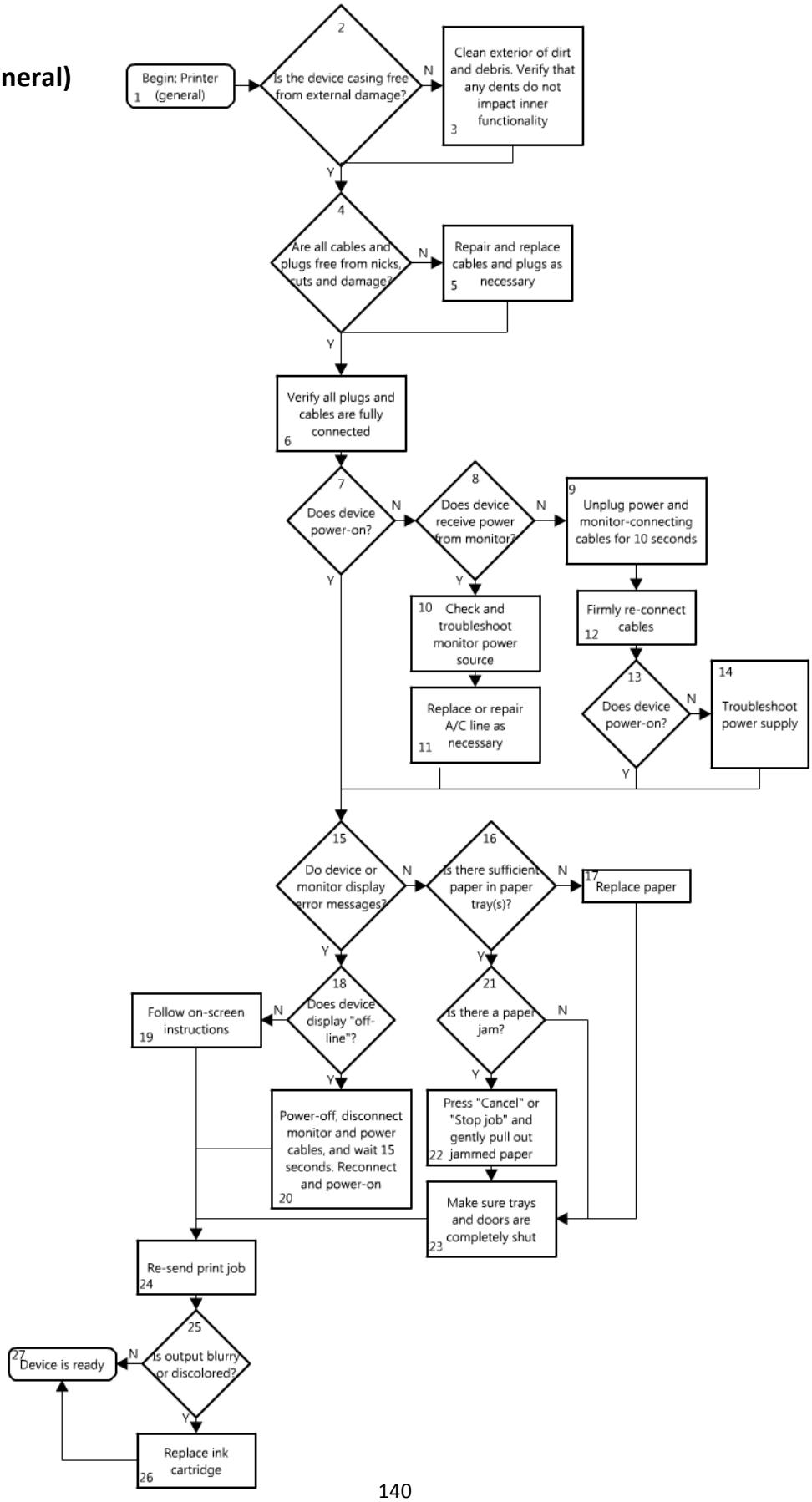
Preventive Maintenance

- Keep transformer clean. Avoid using water to do so.
- Store in a dry place with no possibility of contact with water.
- Store within the range of -40-55°C

Thoughts/ Comments/ Ideas

Printer (general)

Flowchart



Description

#	Textbox	Explanation
1	Begin: Printer (general)	Begin troubleshooting process for a work order for Printer (general)
2	Is the device casing free from external damage?	Scan the exterior of the device for any dents, damage or debris. Damage to the exterior can be indicative of more severe internal damage.
3	Clean exterior of dirt and debris. Verify that any dents do not impact inner functionality	Devices operate best when uninhibited by dirt and debris. See BTA skills for Mechanical Cleaning and Mechanical Casing.
4	Are all cables and plugs free from nicks, cuts and damage?	Damage to wires can inhibit transfer of electrical signal throughout device.
5	Repair and replace cables and plugs as necessary	See BTA skills for Electrical Simple connections and Power Supply.
6	Verify all plugs and cables are fully connected	Plugs and cables should fit firmly in their ports. Oftentimes a loose cable can hamper proper electrical functionality. For more in depth information, see BTA skills on Electrical Simple Connectors.
7	Does device power-on?	Signs of a device that is “on” include but are not limited to lights and sounds.
8	Does device receive power from monitor?	For some medical applications, printers receive power from the monitor or larger device to which they are connected, instead of from a battery or an A/C line or fuse.
9	Unplug power and monitor-connecting cables for 10 seconds	Unplug all cables from printer. Power cords should also be unplugged from the wall.
10	Check and troubleshoot monitor power source	See flowchart for Power Supply and BTA skills for Power Supply.
11	Replace or repair A/C line as necessary	See BTA skills for Electrical Simple Connections and Electrical Simple Fabrication.
12	Firmly re-connect cables	Plugs and cables should fit firmly in their ports. Oftentimes a loose cable can hamper proper electrical functionality. For more in depth information, see BTA skills on Electrical Simple Connectors.
13	Does device power-on?	Signs of a device that is “on” include but are not limited to lights and sounds.
14	Troubleshoot power supply	See flowchart for Power Supply and BTA skills for Power Supply.
15	Do device or monitor display error messages?	Many devices have built in mechanisms that trigger error message displays upon malfunction of the device.
16	Is there sufficient paper in tray(s)?	Lack of paper, or paper of an improper size or thickness, can cause jams or the burn out of internal parts.
17	Replace paper	Make sure to pay attention to size, thickness and surface finish that matches either the device or its settings.

18	Does device display “off-line”?	An “off-line” error message may not be accompanied by appropriate on-screen instructions.
19	Follow on-screen instructions	Devices with well-designed error messages will usually also provide step-by-step on-screen instructions for repair.
20	Power-off, disconnect monitor and power cables, and wait 15 seconds. Reconnect and power-on	An “off-line” error message may not be accompanied by appropriate on-screen instructions. The problem can usually be solved by re-setting all connections as described in this step.
21	Is there a paper jam?	Paper jams can be obvious or discrete. They occur when paper is improperly fed through the printer. Even the smallest of scraps of paper can lead to a jam.
22	Press “Cancel” or “Stop job” and gently pull out jammed paper	It is important that the device stop trying to print before the paper is removed. When removing paper, also keep an eye out for misalignment in the gears or other internal components, that may have caused the paper to jam in the first place.
23	Make sure trays and doors are completely shut	Sometimes the printer will not function because all of its openings are not properly closed. To troubleshoot more in depth, see BTA skills for Mechanical Casing.
24	Re-send print job	To test if printer is functional without restarting troubleshooting process, cancel all print jobs and re-send the most recent.
25	Is output blurry or discolored?	A blurry or discolored output appears like an image out of focus.
26	Replace ink cartridge	A blurry or discolored output indicates that the printer itself is working properly, but that there is an issue with the ink.
27	Device is ready	Device is ready for use.

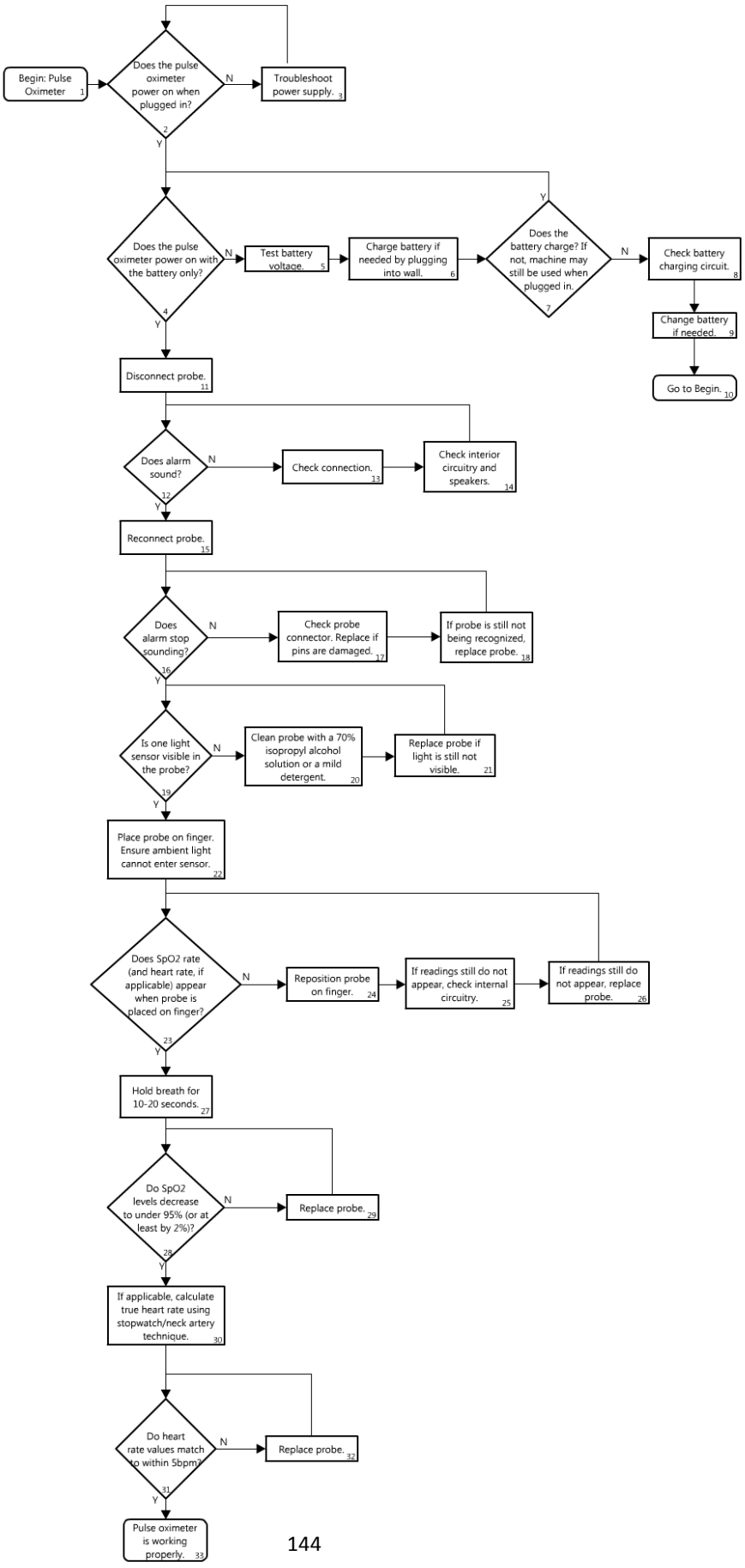
Preventive Maintenance

- Keep stock of printer supplies (ink and paper)
- Regularly check for jams
- Make sure that all printer settings match the function of the job, and the type and size of paper being used

Thoughts/ Comments/ Ideas

Pulse Oximeter

Flowchart



Description

#	Text Box	Explanation or Comment
1	Begin: Pulse Oximeter	Begin diagnostic process on a work order for pulse oximeter. Maintenance is generally requested on a pulse oximeter when it cannot read SpO_2 or heart rate levels.
2	Does the pulse oximeter power on?	The displays should appear on working pulse oximeter when powered on.
3	Troubleshoot power supply (separate chart).	If no power reaches the machine, there may be problems with the switch, fuse, or wiring. See flowchart for Power Supply and BTA skills on Power Supply.
4	Does the pulse oximeter power on with the battery only?	Though the machine can still be used even if the battery charging circuit is faulty, the battery should be checked for functionality.
5	Test battery voltage.	Use a multimeter to determine if proper voltage is reaching the pulse oximeter. See flowchart for Batteries and BTA skills on Power Supply.
6	Charge battery if needed by plugging into wall.	The battery needs fourteen hours to recharge completely.
7	Does the battery charge?	If the battery does not hold charge, the machine may still be used when plugged in.
8	Check battery charging circuit.	Ensure that the circuitry that charges the battery is intact.
9	Change battery if needed.	Check the battery's replacement date and change it if it is faulty or if the date has passed.
10	Go to begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
11	Disconnect probe.	Remove probe from pulse oximeter.
12	Does the alarm sound?	The alarm should not only sound when heart rate or SpO_2 levels reach outside the acceptable ranges but when the probe connection with the machine is lost.
13	Check connection.	Ensure that there is nothing blocking the probe receptacle. Clear any debris or dirt that may interfere with probe connection.
14	Check internal circuitry and speakers.	Ensure internal circuitry and speaker connections are intact. See BTA skills for Electrical Simple.
15	Reconnect probe.	Reinsert probe into pulse oximeter.
16	Does the alarm stop sounding?	Ensure that the probe connection alarm stops when the probe is reconnected.
17	Check probe connector. Replace if pins are damaged.	If the pins on the probe connector are damaged, bent, or broken, the probe should be replaced.
18	If probe is still not being recognized, replace probe.	If the alarm continues, the problem may be with the probe itself. Replace the probe.
19	Is one light sensor visible in	There should be one red light being visibly emitted

	the probe?	from inside the probe.
20	Clean probe with a 70% isopropyl alcohol solution or a mild detergent.	Probe can also be cleaned with warm water, liquid soap, mild chlorine bleach solution, or a hydrogen peroxide solution. Do not use acetone, butyl alcohol, denatured ethanol, Freon, trichloroethylene or any petroleum-based solutions. See BTA skills on Mechanical Cleaning.
21	Replace probe if light is still not visible.	If light is not being emitted, the photodetector cannot read the signals. The pulse oximeter cannot calculate the SpO_2 value or heart rate.
22	Place probe on finger. Ensure ambient light cannot enter sensor.	When not in use, the probe should be shielded from direct light. If any outside light enters the sensor, it can drastically affect readings, as they are calculated through photodetection sensors.
23	Does SpO_2 rate (and heart rate, if applicable) appear when probe is placed on finger?	The rate(s) should appear on the display one the probe is placed on the finger.
24	Reposition probe on finger.	The probe may be placed incorrectly on the finger. Ensure it is not too tight or loose and no outside light is entering the sensor.
25	If readings still do not appear, check internal circuitry.	Ensure internal circuitry is intact and connections are strong. See BTA skills on Electrical Simple.
26	If readings still do not appear, replace probe.	Ensure correct probe is being used. Other probes may not connect correctly.
27	Hold breath for 10-20 seconds.	This is to manually check if the SpO_2 readings decrease with less oxygen supply.
28	Do SpO_2 levels decrease to under 95% (or at least by 2%)?	As you hold your breath longer, the rate should decrease a few percent at least.
29	Replace probe.	Attempt again with a new probe.
30	If applicable, calculate true heart rate using stopwatch/neck artery technique.	If applicable, calculate heart rate manually using a stopwatch and counting pulse rate of neck artery (or wrist).
31	Do heart rate values match to within 1bpm?	Compare manually calculated values to pulse oximeter display.
32	Replace probe.	If values are not with 1bpm, replace probe.
33	Pulse oximeter is working properly.	Return the machine to the appropriate clinical personnel.

Preventive Maintenance

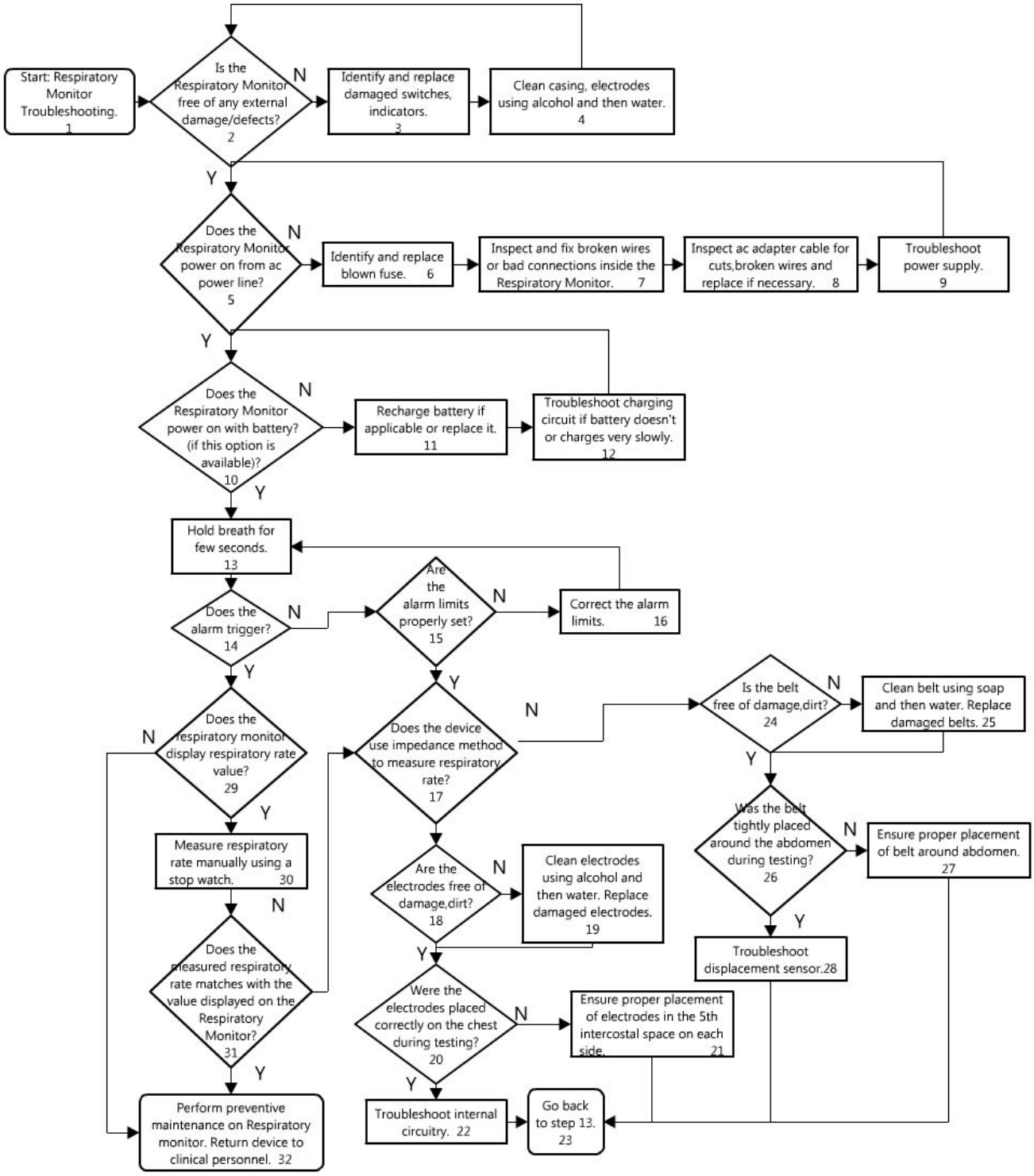
- Inspect exterior of equipment for damaged or missing hardware.

- Inspect the power cord, strain relief and plug/s for any signs of damage.
- Turn unit off, unplug***, open user accessible covers and inspect unit for damage.
- Clean unit interior components and exterior with compressed air.
- Inspect interior for signs of corrosion or missing hardware. Repair as required.
- Inspect electrical components for signs of excessive heat or deterioration.
- Clean exterior with warm water and liquid soap or mild detergent.
- Replace probe if disposable.
- Ensure nothing is blocking LEDs or photodetector on probe. If blocked, clean with isopropyl alcohol solution or mild detergent, mild chlorine bleach solution, hydrogen peroxide solution, or isopropyl alcohol. Do not use acetone, butyl alcohol, denatured ethanol, Freon, trichloroethylene or any petroleum-based solutions. Verify red light is being emitted in probe.
- Place probe on finger and make sure SpO_2 and heart rates (if applicable) appear.
- Remove probe from finger and verify that alarm is working.
- Unplug probe and verify that alarm is working.
- Examine switches and controls for proper function.
- Confirm lights, indicators, and displays are working.
- Verify machine can run on line power without battery.
- Check suggested replacement date for battery to see if date is passed or approaching and replace battery if necessary.

Thoughts/ Comments/ Ideas

Respiratory Monitor

Flowchart



Description

#	Text Box	Comments
1	Start: Respiratory Monitor troubleshooting	Begin diagnostic process for a work order for Respiratory Monitor.
2	Is the respiratory monitor free of any external damage/defects?	Inspect respiratory monitor for external cracks, broken switch etc.
3	Identify and replace damaged switches, indicators.	Refer BTA skill set on Switches and Lighting/Indicators to identify and replace damaged switches and indicators.
4	Clean casing, electrodes using Alcohol and then water.	Examine casing, electrodes and cables for dirt and contamination. Refer BTA skill set on Cleaning to clean the respiratory monitor.
5	Does the respiratory monitor power on from ac power line?	Power the device from ac line and turn it on.
6	Identify and replace blown fuse.	Refer BTA skill set on Fuse to identify and replace blown fuse.
7	Inspect and fix broken wires or bad connections inside the respiratory monitor.	Inspect wires and connections from power supply circuit board to other boards using multimeter. Refer BTA skill set on Connections for identifying and fixing broken wires and bad connections.
8	Inspect AC adapter cable for cuts, broken wires and replace if necessary.	Refer BTA skill set on Connections and Connectors for identifying and replacing damaged cables.
9	Troubleshoot power supply.	Most respiratory monitors can power on from battery and ac power mains.
10	Does the respiratory monitor power on with battery (if this option is available)?	Disconnect respiratory monitor from ac power line. Turn the device on. If respiratory monitor fails to power on then battery is fully depleted or damaged.
11	Recharge battery if applicable or replace it.	Refer BTA skill set on Batteries to replace and identify damaged batteries.
12	Troubleshoot charging circuit if battery doesn't or charges very slowly.	Refer BTA skill set on Transformer and Regulators to troubleshoot charging circuit.
13	Hold breath for few seconds.	Place electrodes/belt as required and turn the device on. Hold breath for few seconds.
14	Does the alarm trigger?	All respiratory and apnea monitors are designed to detect and trigger an alarm when there is a breathing pause for a period of time.
15	Are the alarm limits properly set?	Alarm limits can be modified by the user.
16	Correct the alarm limits.	Refer device manual for correcting alarm limits.
17	Does the device use impedance method to measure respiratory rate?	There are two types of respiratory monitors commonly found in the developing world. *Transthoracic electrical impedance* makes use of electrodes. *Pneumatic abdominal* type makes use of a belt.
18	Are the electrodes free of damage, dirt?	Electrodes should be clean and dry. Inspect the electrode cables and connectors for cuts and broken wires.
19	Clean electrodes using alcohol and then water. Replace damaged electrodes.	Refer BTA skill set on Connections and Connectors for identifying and replacing damaged cables.
20	Were the electrodes placed correctly on the chest	User error is one of the main reasons for false

	during testing?	alarms.
21	Ensure proper placement of electrodes in the 5th intercostal space on each side.	The 5th intercostal space is between the 5th and 6th ribs.
22	Troubleshoot internal circuitry.	Improper functioning of internal circuitry is a common reason for the failure of transthoracic impedance type respiratory monitor. See BTA skills on Electrical Simple.
23	Go back to step 13.	Restart calibration process.
24	Is the belt free of damage, dirt?	Belts should be clean and dry. Inspect the cables and connectors for cuts and broken wires.
25	Clean belt using soap and then water. Replace damaged belts.	Refer BTA skill set on Connections and Connectors for identifying and replacing damaged cables.
26	Was the belt tightly placed around the abdomen during testing?	User error is one of the main reasons for false alarms.
27	Ensure proper placement of belt around abdomen.	Excessively tight belt can lead to complications.
28	Troubleshoot displacement sensor.	Improper functioning of displacement sensor (LVDT or strain gauge) is a common reason for the failure of pneumatic abdominal sensor type respiratory monitor.
29	Does the respiratory monitor display respiratory rate value?	Apnea monitors are provided with only the alarm feature. But respiratory monitors have the alarm feature and can also display the respiratory rate value.
30	Measure respiratory rate manually using a stop watch.	Manually count the number of breaths for a period of 20s using stopwatch. Multiply result by 3.
31	Does the measured respiratory rate matches with the value displayed on the Respiratory Monitor?	Improper functioning of internal circuitry or damaged electrodes/belts if there is a mismatch between the measured respiratory rate and the rate displayed on the Respiratory Monitor.
32	Perform preventive maintenance on Respiratory monitor. Return device to clinical personnel.	Respiratory Monitor is working properly. Perform preventive maintenance before returning the device to clinical personnel.

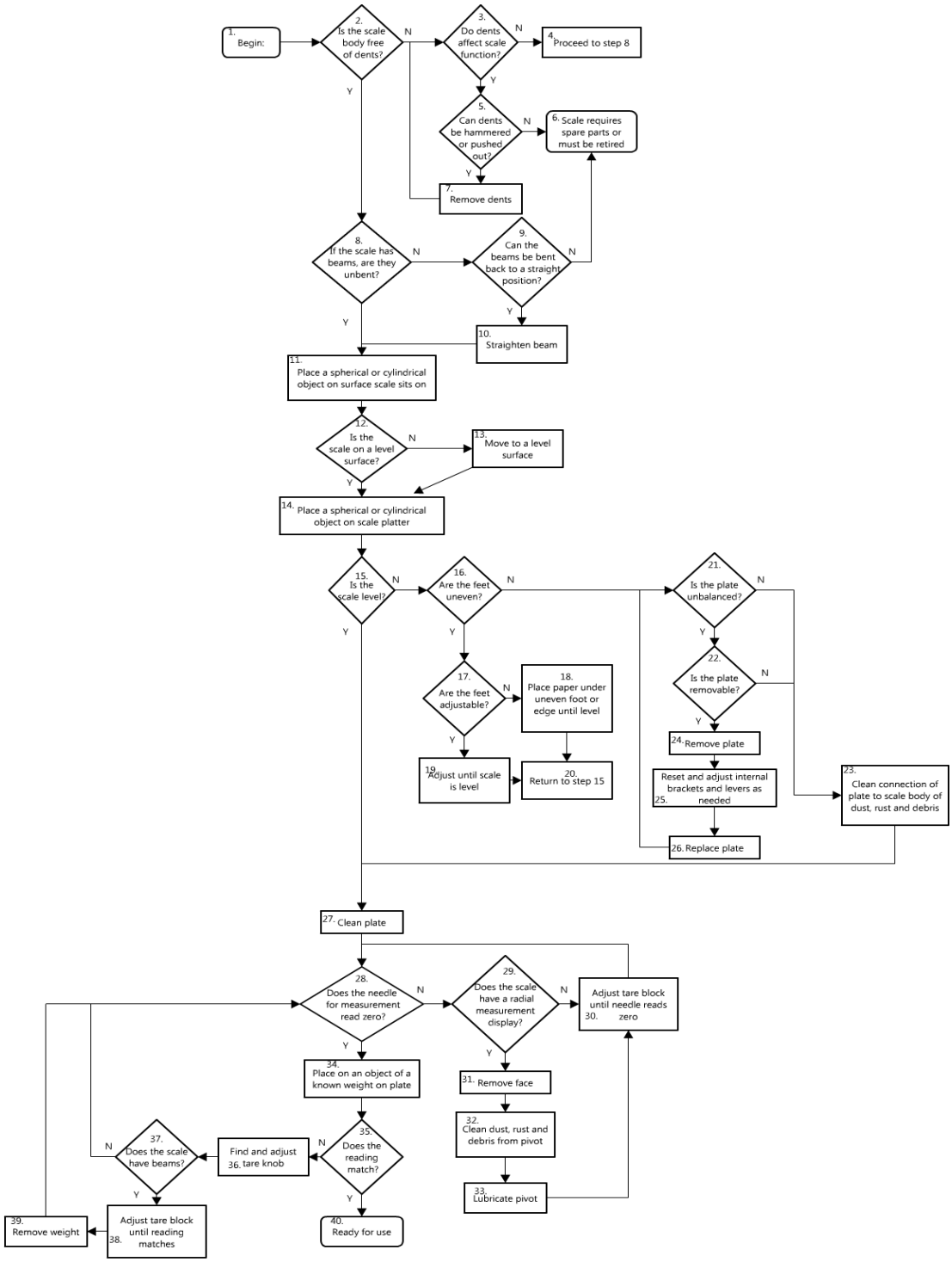
Preventative Maintenance

- Keep belt devoid of dirt and debris. Clean regularly with soap and water
- Clean electrodes after each use
- Check all cords for defects and replace as needed
- Regularly check device-measured respiratory rate with a manual measurement

Thoughts/ Comments/ Ideas

Scales (Analog)

Flowchart



Description

#	Text box	Explanation or comment
1	Begin	Begin diagnostic process for a work order on scales (analog). Analog scales contain no electrical components, so nothing needs to be turned "on." Make sure that scale plate is clear of any objects or debris and any weighted elements are set to zero.
2	Is the scale body free of dents?	By looking and feeling the exterior of the scale, assess for major external damage.
3	Do dents affect scale function?	Depress the scale platter gently. Does the external damage appear to hinder the movement of the scale's needle?
4	Proceed to step 8	Proceed to step 8
5	Can dents be hammered or pushed out?	By looking and feeling the exterior of the scale, gently test to see if the dents can be removed easily.
6	Scale requires spare parts or must be retired	The external damage is beyond simple repair and impairs scale function.
7	Remove dents	Gently push or hammer out the dents in the scale body.
8	If the scale has beams, are they unbent?	Visually assess for external damage in beams.
9	Can the beams be bent back to a straight position?	Gently try to push beams back into a straight position.
10	Straighten beam	Gently try to push beams back into a straight position.
11	Place a spherical or cylindrical object on surface scale sits on	Any object that rolls will suffice. Ideal objects would be a marble, small ball, pen, pencil, dowel, etc.
12	Is the scale on a level surface?	If the object rolls of its own accord, the surface the scale sits on is not level.
13	Move to a level surface	Move scale to a surface on which the spherical or cylindrical object does not roll of its own accord.
14	Place a spherical or cylindrical object on scale platter	Repeat test for levelness on scale platter.
15	Is the scale level?	If the object rolls of its own accord, the scale platter is not level and adjustments need to be made.
16	Are the feet uneven?	To see if the problem lies in the interface between the scale and the surface it sits on, press on each of the corners of the scale body and verify visually and audibly whether or not the scale wobbles.
17	Are the feet adjustable?	On some models, the feet can be adjusted like knobs to raise or lower a corner of the scale.
18	Place paper under uneven foot or edge until level	If the scale feet cannot be adjusted, the scale can be leveled by placing paper or cardboard under the problem corner until the scale plate is level. Use spherical or cylindrical object to determine levelness.
19	Adjust until scale is level	Twist knobs until scale is level. Use spherical or cylindrical object to determine levelness.
20	Return to step 15	In order to double check the level-ness of the scale, return to step 15.
21	Is the plate unbalanced?	If the problem is not in the feet, the lack of levelness is due to either the plate itself or the connection between the plate and the rest of the scale body.
22	Is the plate removable?	Inspect to see if plate can be removed. May need to slide, twist,

		remove screws or pins, etc. See BTA skills on Mechanical Attachment.
23	Clean connection of plate to scale body of dust, rust and debris	By gently blowing, wiping and/or scraping all pieces that interface between the plate and the internal mechanism. See BTA skills on Mechanical Cleaning.
24	Remove plate	Remove by the mechanism detected in step 21.
25	Reset and adjust internal brackets and levers as needed	Some of the pieces inside the scale body may have been dislodged or moved, for instance, if the scale has been dropped. There are likely to be grooves or marks where they should align, both inside the scale body and on the underside of the scale plate.
26	Replace plate	Replace plate.
27	Clean plate	Using a wet cloth, wipe down plate. See BTA skills on Mechanical Cleaning.
28	Does the needle for measurement read zero?	Visually determine if the needle for measurement is aligned with the zero tic-mark.
29	Does the scale have a radial measurement display?	Most analog scales display measurement in one of two ways – with a radial dial or a system of beams with a sliding weight.
30	Adjust tare block until needle reads zero	Tare block looks like a small, metal bracket with an adjustable knob on the back that holds the bracket in place. Slowly slide the bracket along the beam until the needle reads zero.
31	Remove face	Remove face, may need to twist.
32	Clean dust, rust and debris from pivot	By gently blowing, wiping and/or scraping in pivot. See BTA skills on Mechanical Cleaning.
33	Lubricate pivot	Using WD40, Vaseline, or an acceptable substitute. See BTA skills on Lubrication.
34	Place on an object of a known weight on plate	Suggested items would be any pre-packaged object with a pre-scribed weight, though this rests on the assumption that the written, packaged weight is accurate. An acceptable alternative would be to use a known volume of water, remembering that the density of water is 1 g/cm^3 or 8.34 lb/gal.
35	Does the reading match?	The display should read the value of the known weight of the object.
36	Find and adjust tare knob	Most models, whether radial or beam, have a tare knob located on the back or base of the scale body. This can be turned to manually move display needle.
37	Does the scale have beams?	Most analog scales display measurement in one of two ways – with a radial dial or a system of beams with a sliding weight.
38	Adjust tare block until reading matches	Tare block looks like a small, metal bracket with an adjustable knob on the back that holds the bracket in place. Slowly slide the bracket along the beam until the needle reads the desired value.
39	Remove weight	Remove weight.
40	Ready for use	Scale is ready for use.

Preventative Maintenance

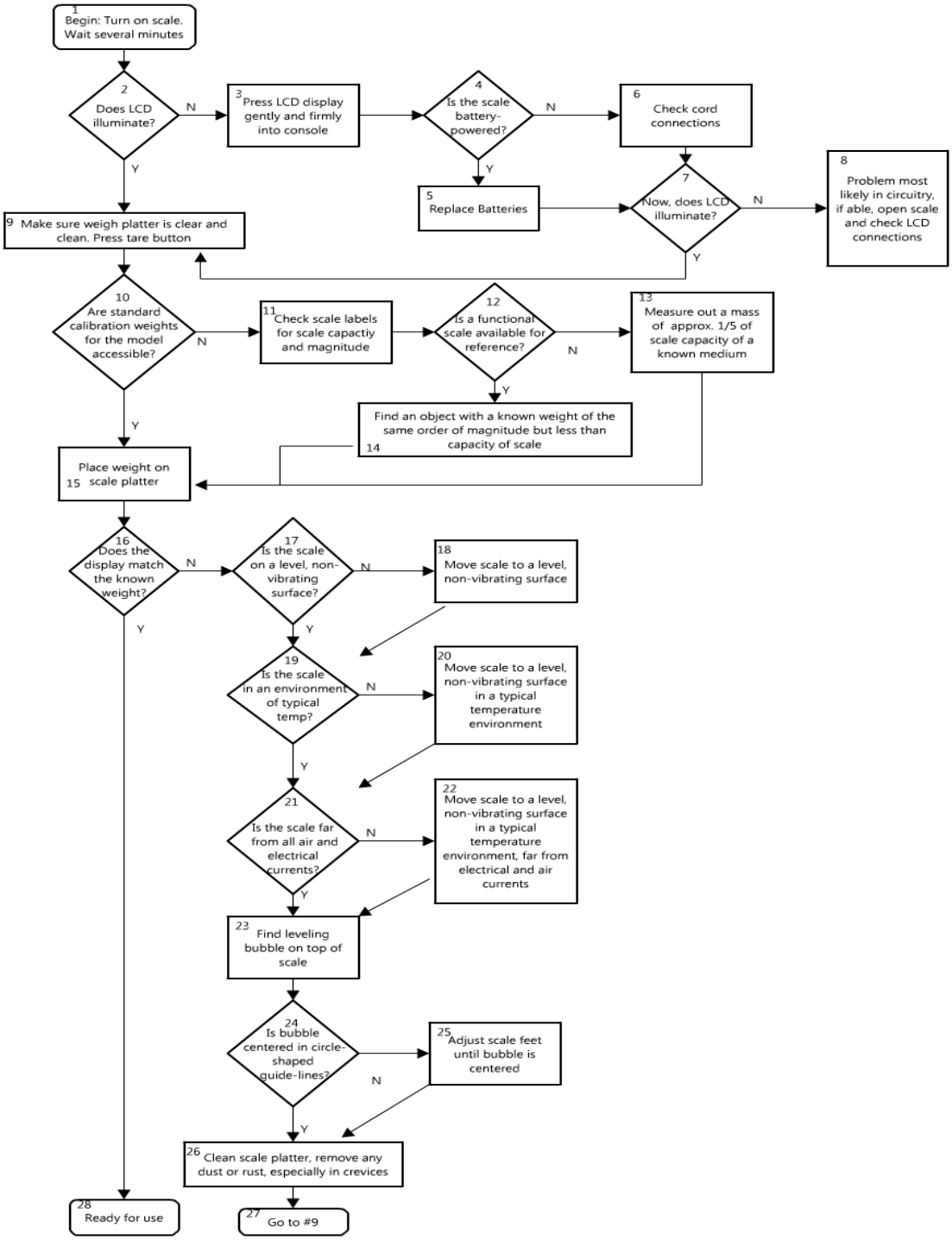
- Clean plate of debris after each use. Use a brush, if possible, to avoid placing plate under excess pressure
- Check the space between the plate and the base for dirt and debris. If debris is preventing the plate from displacing, use a small, thin object such as an unfolded paperclip or a pin to clear it

- Check scale regularly for levelness
- Check scale calibration regularly

Thoughts/Comments/Ideas

Scales (Digital)

Flowchart



Description

#	Text box	Explanation or comment
1	Begin: Turn on scale. Wait several minutes	Start the diagnostic process for a work order on Scales (digital). It is important to allow scale to warm up before use.
2	Does LCD illuminate?	The first part of the diagnostic process will investigate the electronic components of the scale, beginning with the LCD display. Look for numbers, a decimal point, zeros, dashes or a weight unit of measurement on display.
3	Press LCD display gently and firmly into console	If connection between LCD display and internal circuitry is loose, a simple push may suffice to reconnect.
4	Is the scale battery powered?	Look for battery cavity covering and check batteries for rust, leakage and expiration. See BTA skills for Batteries.
5	Replace batteries	If the batteries are too old, power cannot be supplied. See BTA skills on Batteries.
6	Check cord connections	Power cord may disconnected from scale console, it is important that it stays in contact with internal circuitry to maintain power supply.
7	Now does LCD illuminate?	See #2
8	Problem most likely in circuitry, if able, open scale and check internal LCD connections	Troubleshoot circuitry for loose, rusted or otherwise damaged connections. See BTA skills for Connections.
9	Make sure weigh platter is clear and clean. Press tare button	Tare button is on keypad and is labeled as “ZERO”, “0/T”, “TARE”, etc. Pressing this button resets calibration to zero.
10	Are standard calibration weights available?	Every scale should come with official calibration weights with explicit instruction for care and storage, if available, these should be used.
11	Check scale labels for scale capacity and magnitude	Text on scale exterior should give an indication of the precision and degree of magnitude for which the model is designed.
12	Is a functional scale available for reference?	It is best to verify calibration of scale with an object with a known and verified weight
13	Measure out a mass of approx. 1/5 of scale capacity of a known medium	If a functional scale is available, a makeshift calibration weight can easily be found. Suggested mediums for weight include any item with a labeled package weight (i.e. bags of sugar or flour for scales with higher magnitude and lower precision or pre-packaged medical substances or powders for scales of lower magnitude and higher precision), or plastic containers filled with water (size the container appropriately and proportionately to the scale magnitude). It is important to record the weight of this mass for reference.
14	Find an object with a known weight of the same order of magnitude but less than capacity of scale	Suggested items would be any pre-packaged object with a pre-scribed weight, though this rests on the assumption that the written, packaged weight is accurate.
15	Place weight on scale platter	Place weight on scale platter.
16	Does the display match the known weight?	If the scale is properly calibrated, the display should show the known weight for the item.
17	Is the scale on a level, non-vibrating surface?	If the scale is on an uneven or vibrating surface, it is likely to display an incorrect weight reading.
18	Move scale to a level, non-vibrating surface	Examples of level, non-vibrating surfaces include a paved or finished floor, a counter-top, or a table.

19	Is the scale in an environment of typical temperature?	If the scale is in an environment with an abnormal temperature, the circuitry may not function properly. A typical temperature is approximately within the range of 10-32.2 degrees C.
20	Move scale to a level, non-vibrating surface in an environment with a typical temperature	If possible, store and use scale in a temperature-controlled room. Otherwise, store and use scale in shaded area away from moisture.
21	Is the scale far from all electrical and air currents?	Electrical currents affect the internal circuitry and air currents can distort the effective mass on top of the scale.
22	Move scale to a level, non-vibrating surface in an environment with a typical temperature and no currents	Electrical currents can come from high-power machinery or appliances. Air currents can come from open windows, open doors, heating or cooling vents. Store and use scale as far from all of these as possible.
23	Find leveling bubble on top of scale	This should be on the console as opposed to the scale platter, probably towards the rear of the scale. There should be two concentric circles showing fluid and an air bubble beneath.
24	Is bubble centered in circle-shaped guide-lines?	The bubble should be about the size of the smaller circle, the scale is level when the two line up.
25	Adjust scale feet until bubble is centered	All four scale feet should be adjustable by rotation to slowly change the height of each supporting leg of the scale. There may also be a fifth “phantom” leg towards the front of the scale that can be lowered to add balance while adjusting the feet.
26	Clean scale platter, remove any dust or rust, especially in crevices	Scale platter should be cleaned with clean, warm water, a cloth and gentle scrubbing. A cloth can typically remove dust or rust from crevices, as can blowing a jet of air gently through any cracks or crevices. See BTA skills for Mechanical Cleaning.
27	Go to #9	Restart calibration process to ensure that scale is properly calibrated.
28	Ready for use	Scale is ready for use.

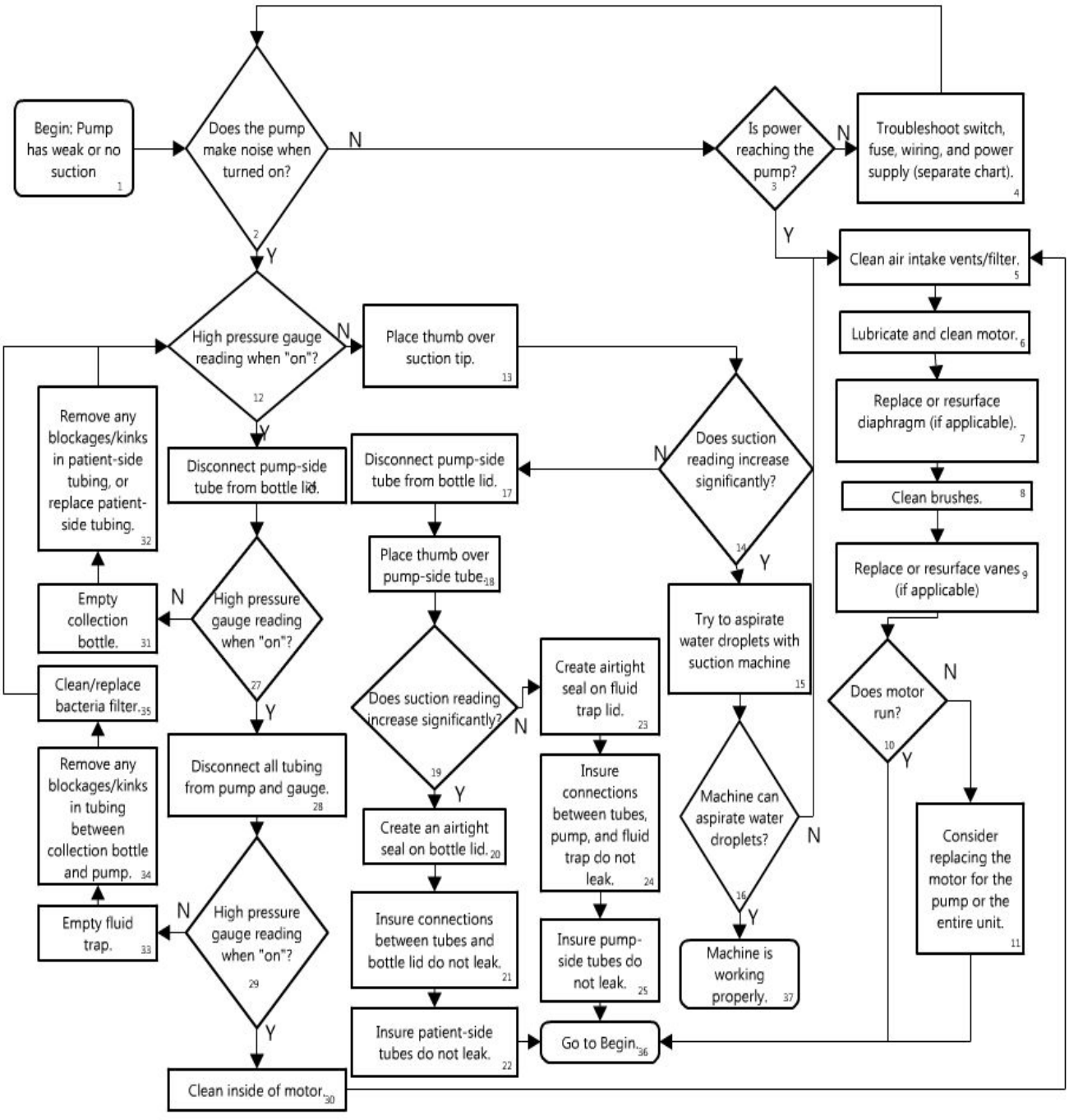
Preventative Maintenance

- Regularly check and replace batteries
- Check power cord for defects
- Check calibration regularly
- Check for levelness
- Ensure that device is free of debris, corrosion, dirt, etc.

Thoughts/Comments/Ideas

Suction Machine

Flowchart



Description

#	Text box	Explanation or Comment
1	Begin: Pump has weak or no suction	Begin diagnostic process for a work order on Suction Pump. Maintenance is generally requested on a suction pump when it is offering weak or no suction.
2	Does the pump make noise when turned on?	A working suction machine has a motor or pump that makes noise when the device is turned on.
3	Is power reaching the pump?	Wires should enter the motor to provide power. Use a multimeter to determine if the proper voltage is reaching these wires. See BTA skills on Electrical Simple.
4	Troubleshoot switch, fuse, and power supply (separate chart).	If no power reaches the pump, there may be problems with the switch, fuse, or wiring. If the motor is DC, check the power supply. See BTA skills on Power Supply.
5	Clean air intake vents/filter.	The pump's air intake vent or filter should be cleaned for dust or other obstructions. See BTA skills on Filters.
6	Lubricate and clean motor.	See BTA skills on Motor Cleaning.
7	Replace or resurface diaphragm (if applicable).	The diaphragm or membrane pump should be cleaned periodically. Diaphragm pumps use reed valves to build suction, which can become corroded or pitted. If the head metal also gets pitted, the diaphragm needs to be replaced.
8	Clean brushes.	See BTA skills on Motor Brushes
9	Replace or resurface vanes (if applicable).	The vanes on rotary vane pumps may wear out over time. The vanes may be replaced, but are often expensive and difficult to find. Vanes can also become pitted and grooved. These can be refaced fairly easily.
10	Does motor run?	After each attempt to repair the motor, test to see if it works.
11	Consider replacing the motor for the pump or the entire unit.	If the motor can't be repaired, it is time to replace the motor or the entire unit.
12	High pressure gage reading when "on"?	Most suctions pumps have a pressure gage. When the machine is first turned on, does the gage give a high reading? If there is no pressure gage, you will have to diagnose the strength of the suction at different points in the pneumatic circuit, then look for leaks and blockages based on this information. See BTA skills on Plumbing Blockages.
13	Place thumb over suction tip.	Occlude the end of the tubing that goes in the patient.

14	Does suction reading increase significantly?	If the machine is working properly, the pressure gage should rapidly increase to a higher reading when the end is occluded.
15	Try using completely assembled machine to aspirate water droplets.	Use the machine to aspirate water from another container. Place the tip just at the surface of the water. The pump might not aspirate if the tip is submerged beneath the surface.
16	Machine can aspirate water droplets?	Does the collection bottle gradually fill with water?
17	Disconnect pump-side tube from bottle lid.	Two tubes connect to the lid of the collection bottle. Disconnect the tube that goes towards the pump from the lid.
18	Place thumb over pump-side tube.	Occlude the end of the tubing that used to connect to the lid of the collection bottle.
19	Does suction reading increase significantly?	If the machine is working properly, the pressure gage should rapidly increase to a higher reading when the end is occluded.
20	Create an airtight seal on bottle lid.	See BTA skills on Plumbing Seals. Duct tape may help seal leaks between the collection bottle and lid. It may be necessary to replace the collection bottle with another airtight container and lid.
21	Ensure connections between tubes and bottle lid do not leak.	See BTA skills on Plumbing Connections. Try a tighter piece of tubing.
22	Ensure patient-side tubes do not leak.	See BTA skills on Plumbing Leaks.
23	Create airtight seal on fluid trap lid.	See BTA skills on Plumbing Seals. Duct tape may help seal leaks between the collection bottle and lid.
24	Ensure connections between tubes, pump, and fluid trap do not leak.	See BTA skills on Plumbing Connections. Try a tighter piece of tubing.
25	Ensure pump-side tubes do not leak.	See BTA skills on Plumbing Leaks.
26	Disconnect pump-side tube from bottle lid.	Two tubes connect to the lid of the collection bottle. Disconnect the tube that goes towards the pump from the lid.
27	High pressure gage reading when "on"?	Most suctions pumps have a pressure gage. When the machine is first turned on, does the gage give a high reading?
28	Disconnect all tubing from pump and gage.	Remove the tubing and/or fluid trap that connects directly to the pump.

29	High pressure gage reading when "on"?	Most suctions pumps have a pressure gage. When the machine is first turned on, does the gage give a high reading?
30	Clean inside of motor.	The motor may be clogged with dust, dried blood, or other obstructions. See BTA skills on Motor Cleaning.
31	Empty collection bottle.	Clean and empty the bottle.
32	Remove any blockages/kinks in patient-side tubing, or replace patient-side tubing.	See BTA skills on Plumbing Blockages.
33	Empty fluid trap.	Clean and empty fluid trap. Make sure ball moves freely.
34	Remove any blockages/kinks in tubing between collection bottle and pump.	See BTA skills on Plumbing Blockages.
35	Clean/replace bacteria filter.	Replace the bacteria filter with another filter of 3 micron size. The machine can run for a short time without this filter, but the motor will eventually fail if there is no filter.
36	Go to Begin.	Restart the diagnostic process to see if the corrective measures have repaired the machine.
37	Machine is working properly.	Return the machine to service via the appropriate clinical personnel.

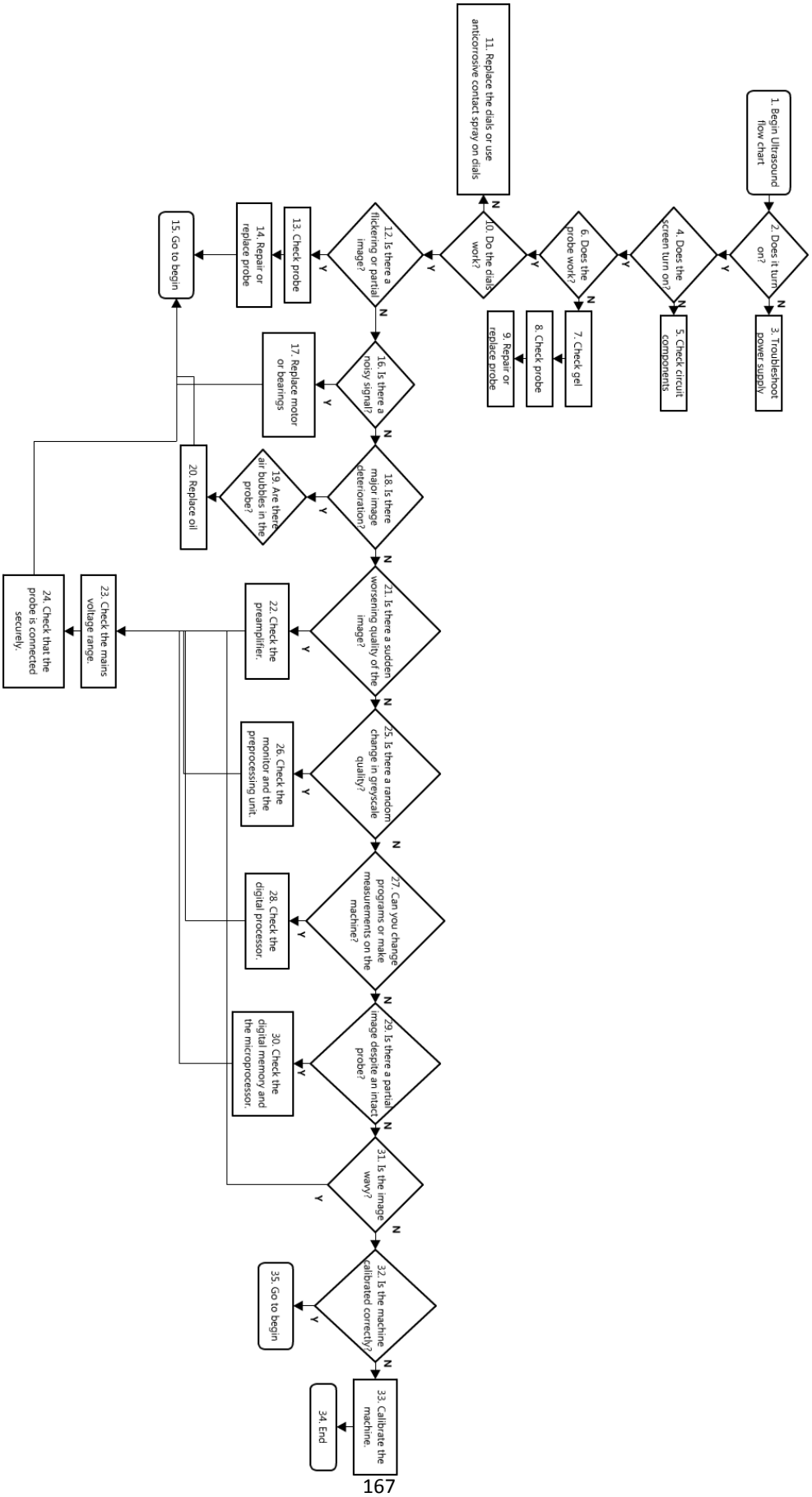
Preventive Maintenance

- Clean air intake filters.
- Ensure electrical plug and cord are in good condition.
- Sterilize jars, tubing, other components that come into contact with patient fluids between each use in solution of water, detergent, and disinfectant.
- Change bacteria filter if wet or discolored. Make sure there is a sufficient supply of bacterial filters
- Check collection bottle/jar for cracks, chips, and other damage.
- Check that float valve moves freely.
- Ensure anti-static tubing is used.
- Clean brushes on motors as necessary.
- Ensure vacuum works over full range of suction pressures if there is a control/knob.
- Verify that overflow valve (float valve) works properly when container is filled with water.
- Grounding resistance between chassis and ground pin should not exceed 0.5 ohms.
- Maximum chassis leakage current with ground wire disconnected should not exceed 300 microamps.
- Check for unusual noises or vibration in motor/pump.
- Check for evidence of fluid spills. Clean any spills as necessary.
- Measure and record vacuum.
- Most suction pumps run in the 20-25inHg range when fully occluded. If the suction is <20inHg then servicing is required.

Thoughts/Comment/Ideas

Ultrasound

Flowchart



Description

1. Begin Ultrasound Flow Chart	Begin Ultrasound Flow Chart
2. Does it turn on?	Does it turn on?
3. Troubleshoot Power Supply	See power supply flowchart
4. Does the screen turn on?	Does the screen turn on?
5. Check circuit components	Troubleshoot the circuit (see troubleshooting guide)
6. Does the probe work?	Does the machine show an image?
7. Check gel.	Is there enough of the proper gel.
8. Check probe.	Ensure that the probe is properly connected and undamaged.
9. Repair or replace probe.	Solder the broken connections or replace the probe.
10. Do the dials work?	Do the dials properly control the machine?
11. Replace dials or use anticorrosive contact spray on dials.	Replace or use anticorrosive contact spray on dials.
12. Is there a flickery or partial image	Does the image on the screen have missing sections? Does the screen flicker?
13. Check probe.	Gently pull on the cable at different points to see when the image flickers. This is where the cable is broken. For composite probes wave a pencil across the transducer. If not seen, this is where the transducer is not connected.
14. Repair or replace probe.	Solder the broken connections or replace the probe.
15. Go to begin.	Go to begin.
16. Is there a noisy signal?	Is there distortion in the produced image?
17. Replace motor or bearings	Replace the motor or bearings if they are broken or damaged.
18. Is there major image deterioration?	Is the image severely deteriorated?
19. Are there air bubbles in the probe?	Does the oil in the probe have air bubbles in it?

20. Replace oil.	Replace oil.
21. Is there a sudden worsening quality of the image?	Does the image have sudden changes in quality?
22. Check the preamplifier.	Check the preamplifier.
23. Check the mains voltage range.	Check the outlet voltage range.
24. Check that the probe is connected securely.	Check that the probe is connected securely.
25. Is there a random change in greyscale quality?	Is there a random change in greyscale quality?
26. Check the monitor and the preprocessing unit.	Check the monitor and the preprocessing unit.
27. Can you change programs or make measurements on the machine?	Can you change programs or make measurements on the machine?
28. Check the digital processor.	Check the digital processor.
29. Is there a partial image despite an intact probe?	Is there a partial image despite an intact probe?
30. Check the digital memory and the microprocessor.	Check the digital memory and the microprocessor.
31. Is the image wavy?	Is the image wavy?
32. Is the machine calibrated correctly?	Is the machine calibrated correctly?
33. Go to begin.	Got to begin.
34. Calibrate the machine.	Calibrate the machine.
35. End	End

Preventive Maintenance

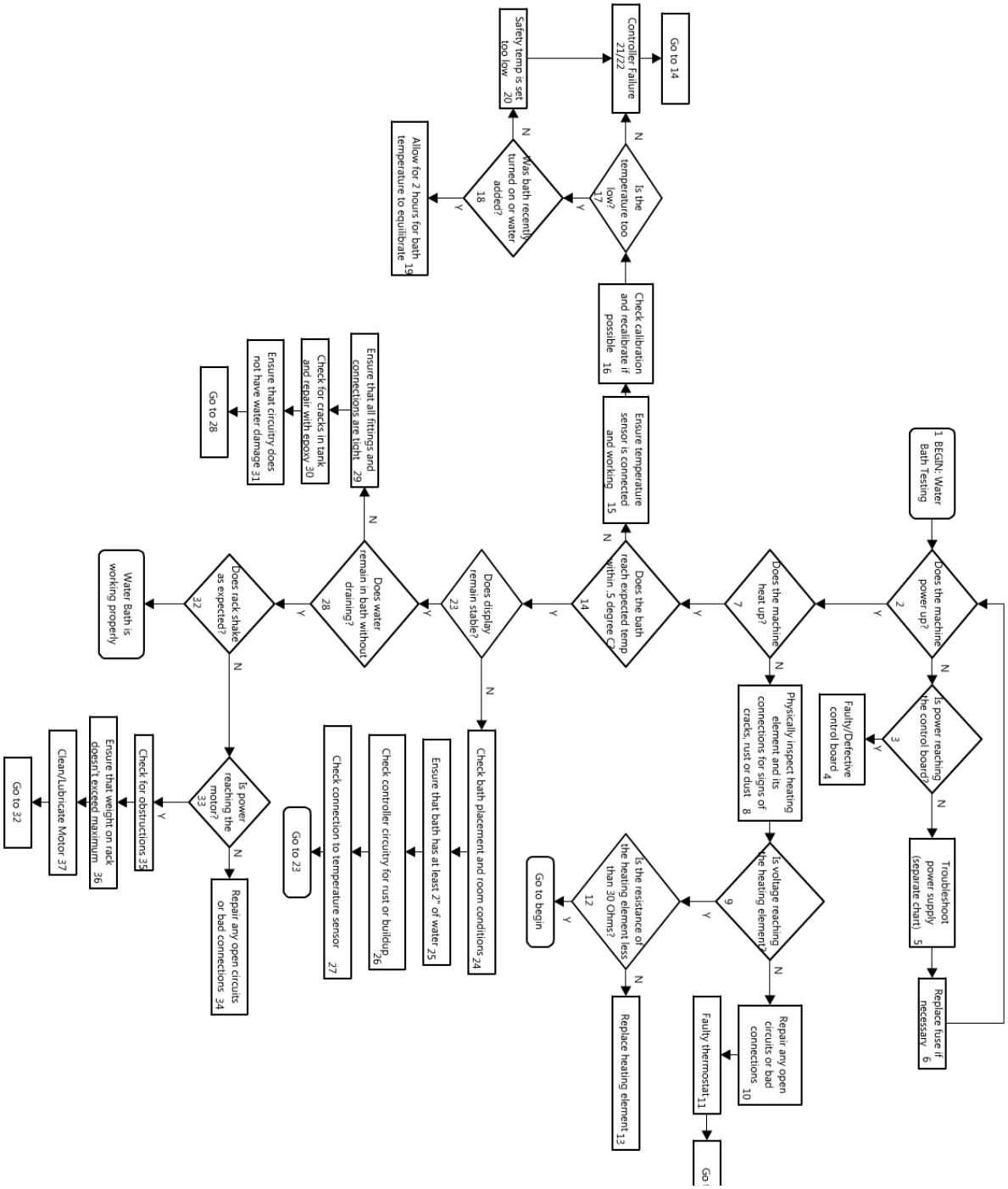
- After every use, clean the probe and cable with a damp cloth to ensure that it
- is free of gel.
- Replace the internal battery to protect internal memory if necessary
    - when replacing
- read the manual to tell you what to do
- Clean the controls by wiping them with a damp cloth or tissue after every
- working day.
- Change the dust filter every 3 to 6 months.
- Ultrasound Proper Usage
    - Ensure proper mains voltage range.
    - When changing the dust filter, if the original filter paper cannot be found, a
- piece of double gauze may be used.

- Ensure there is no air between the probe and the patient by having enough
- ultrasonic gel to ensure a quality image.
  - Do not soak the cable with gel.
  - Do not turn off and on the machine quickly. Leave two minutes between each
- to retain internal memory of the device. Also, leave the machine running for
- at least 15 minutes every time.
  - To adjust the greyscale during a session, use dynamic controls on the
- machine not those controls on the monitor. Otherwise use the grey wedge on
- the monitor.
  - The ultrasound may freeze if the information is typed in too quickly. If the
- machine freezes, turn the machine off and wait two minutes before
- restarting.
  - Do not spill liquids on the machine.
  - Do not hang anything for the controls of the machine.
- 10.If the mains voltage varies more than the tolerance of the machine specified
- by the manufacturer (usually around + 10%), a voltage stabilizer is required.
- 11.Ventilation holes of the ultrasound must not be covered by papers, forms, or
- tissue
- 12.When troubleshooting the electronics of the device, start replacing fuses if
- necessary and checking the highly stressed circuit that powers the pulse
- generator.

Thoughts/ Comments/ Ideas

Water Bath

Flowchart



Description

#	Text Box	Explanation
1	Begin Water Bath Testing	Start the diagnostic process for a work order on a Water bath
2	*Does the machine power up?*	With unit plugged in, and power switch turned on, the display should light up
3	*Is power reaching the control board?*	Use a multimeter at the leads of the control board to ensure that sufficient voltage is reaching the controller. If insufficient, there may be a problem with the wiring.
4	Faulty/Defective control board.	Replace control board if available.
5	Troubleshoot the power supply (separate chart)	
6	Replace fuse if necessary	See BTA skill under *Power Supply* on Identifying a Blown Fuse
7	*Does the machine heat up?*	Expose the heating element by opening up the machine. Turn the unit on and place hand over coils. You should be able to feel heat being produced by coils if machine is functioning correctly
8	Physically inspect heating element and its connections for signs of cracks, rust or dust	If the coils do not produce heat, turn unit off and visually inspect coils for signs of damage. Reference BTA skill under *Mechanical* on Cleaning Rust, and Compressed Air. If cracks are present the heating unit will need to be replaced.
9	*Is voltage reaching the heating element?*	Using a voltmeter, measure the voltage entering the heating unit. To inspect if the circuit is open or closed, see BTA skill under *Electrical Simple* for Building and Using a Continuity Tester
10	Repair any open circuits or bad connections	Bad connections can occur due to buildup of rust, corrosion, or broken components. See BTA skills under *Electrical Simple* for Soldering, Cleaning of Connectors, Loose Connectors.
11	Faulty thermostat.	If no voltage is reaching the heating coil, the problem could also lie in the machine's thermostat. Refer to BTA skill under *Electrical Simple* on Replacing Temperature Sensing Device to repair.
12	*Is the resistance of the heating element less than 30 Ohms?*	Heating elements work by having low resistance between 15-30 ohms. Attaching a multimeter to the heating element should conduct electricity and produce a resistance in this range. If the resistance reads "open" the heating coil should be replaced.
13	Replace heating element	Refer to BTA skill under *Electrical Simple* on Replacement of Heating Element, and ensure that new coil matches resistance and power rating.
14	*Does the bath reach expected temp within 0.5 degrees?*	Using a thermometer, test the bath temperature and determine if it matches display/expected temp within 0.5 degrees. Any difference greater than this is not appropriate.
15	Ensure temperature sensor is connected and working	Use methods described in BTA skill under *Electrical Simple* on Replacement of Temperature Sensing

		Device, to determine if temp sensor is working properly. Replace if necessary.
16	Check calibration and recalibrate if possible	Most digital water baths have the capability to reset their calibration. After ensuring the temp sensor is working properly, recalibrate the system. Determine water bath temperature with external thermometer and make sure the machine is calibrated correctly to this value.
17	*Is the temperature too low?*	The bath temperature is not reaching the set temp.
18	*Was bath recently turned on or water added?*	If the machine just turned on, or room temp/colder water recently added to the bath, it might not have equilibrated yet.
19	Allow for 2 hours for bath temperature to equilibrate	Leave at least 2 hours after start or addition of water for the bath temperature to rise to set temp before continuing with flow chart.
20	Safety temperature is set too low	Ensure that the safety temp (or maximum allowable temperature) temperature setting is not lower than the desired, set temperature. The machine will never exceed the safety temp, even if it is lower than desired temperature.
21/22	Controller Failure	The PID controller is not providing correct or sufficient feedback to the system. Troubleshoot controller circuit (include rust check).
23	*Does display remain stable?*	After the equilibration time (2 hours) the bath temp should remain stable (within 0.5 degrees of the set temp).
24	Check bath placement and room conditions	Ensure that the bath is not placed near a heat generator or distributer (i.e. fan, window, radiator, air conditioner). Ensure that room temperature is not fluctuating.
25	Ensure that bath has at least 2” of water	The water must completely cover the temperature sensor, which is generally about 2” on the base of the bath.
26	Check controller circuitry for rust or buildup.	Visually inspect all controller circuitry. If rust or buildup has formed on connections, clean using BTA skill under *Electrical Simple* for Cleaning Rust and Cleaning of Connectors.
27	Check connection to temperature sensor	Use methods described in BTA skill under *Electrical Simple* on Replacement of Temperature Sensing Device to determine if temperature sensor is working properly. Replace if necessary.
28	*Does the water remain in bath without draining?*	Other than because of evaporation, water height should remain relatively constant over time. Check to see if water level is changing drastically, due to cracks or leaks
29	Ensure that all fittings and connections are tight	Drain bath. Using BTA skills under *Plumbing* for Connections tighten all connections and fittings to ensure leak-proof seal.
30	Check for cracks in tank and repair with epoxy	Look for cracks in the bath tank. Using BTA skill under *Plumbing* on Epoxy, seal any cracks.

31	Ensure that circuitry does not have water damage	If leaks have occurred, disassemble bath and check electrical circuits to ensure no damage has occurred.
32	*Does the rack shake as expected?*	If bath has a shaking feature, this motion should occur without obstruction
33	*Is power reaching the motor?*	Using a multimeter, check the leads of the motor to ensure voltage is reaching the motor
34	Repair any open circuits or bad connections	Refer to steps 9 & 10 for BTA skills.
35	Check for obstructions	Visually inspect the bath and rack connections to find any objects that may be hindering its motion. This could include rust/calcium buildup, rack deterioration, or solid particles.
36	Ensure that weight on rack doesn't exceed maximum	The rack itself can only accommodate a limited amount of weight. This varies with bath size, but generally should not exceed
37	Clean/lubricate motor	See BTA skills under *Motors* on Cleaning/Lubrication.

Preventive Maintenance

Allow machine to run for 2 hours for bath temperature to equilibrate.

- If you use the bath infrequently, then the bath should be kept dry between uses.
- Use only distilled water in a water bath. If non-distilled water has been used, it's important to clean away any water deposits that have accumulated.
- Clean the water bath with mild soap and water solution. *Do not clean the water bath with chlorine-based bleaches*, as they will damage the interior of most tanks. Most water baths should be cleaned with mild soap and water only.
- Rinse the water bath with clean water and wipe dry with a soft cloth. Stainless steel does not rust, but foreign materials in the tank may rust or leave rust spots. Never use steel wool to remove buildups. (See explanations for suggestions)
- Check water level frequently during use, especially during higher operating temperatures, and add water as needed. Running a dry tank can strain interior surfaces
- Turn off the bath each evening. Otherwise water may completely evaporate, leaving the bath dry. This can cause damage to the water bath and create a fire hazard.
- Plastic racks are preferred for water bath use. However, if the water bath boils dry while containing plastic test-tube racks, the plastic will melt.

Thoughts/ Comments/ Ideas

Common Technical Terms

Term	Definition	Examples of Devices Associated
Aperture	An aperture is a small opening whose purpose is generally to allow light to pass through.	Cell Counter, Microscope, Ophthalmoscope
Clutch	The clutch is a component that easily connects and disengages with the driving component of a pump.	Syringe Pump
Light Guide Cable	The light guide cable should not be confused with normal wires. It is thicker and may have both female, both male, or one female and one male connector on the ends.	Endoscope
Manometer	A manometer is a tube or column of liquid used to measure pressure. It is most often filled with mercury.	Manual Blood Pressure Monitor
Probe	A probe is a thin piece of metal that extends out of the body of a device. It is generally used to draw a fluid sample in devices involving liquids, or to apply fixed quantities of localized force in devices used to measure material stiffness.	Cell Counter
Rheostat	A rheostat is an electrical instrument used to measure and adjust electrical resistance. Change in electrical resistance may correlate to other device properties, such as temperature.	Infant Incubator
Roller	The roller is the thin cylinder about which a roll of paper spins. It is connected to the motor.	Fetal Doppler
Rotary Vanes	Rotary vanes often look like fan blades and are the components on a pump that move a fluid as the motor spins the rotor to which the vanes are attached.	Jet Nebulizer, Suction Machine
Sphygmometer	The sphygmometer is the pressure measuring component of a manual BPM. It consists of inlet tubing, a pressure gauge and a small hand pump.	Manual Blood Pressure Monitor
Thermistor	A thermistor is a resistor whose impedance or resistance varies with temperature.	Infant Warmer
Thermocouple	A thermocouple is used to measure temperature and it is made of two different conductors, usually metal, that are joined at one end.	Infant Warmer
Triac	A triac is a “triode for alternating current” that serves to conduct current in either direction. It is a small electrical component that is relatively flat and has three prongs.	Infant Warmer
Zeolite Canister	Zeolite canisters are small containers that hold zeolite stones. Zeolite stones absorb nitrogen and release oxygen. In an O2 Concentrator, the canisters are generally pressurized.	O2 Concentrator

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