Newborn Essential Solutions and Technologies-Education (NEST-ED) Technical Modules provide educational support for each of the technologies included in the NEST360° bundle for newborn care. These materials are intended to strengthen locally developed neonatal and technical trainings in pre-and in-service settings and are not intended to be comprehensive technical guidelines or device-specific manuals.

FACILITATING THE CLINICAL USE AND TECHNICAL REPAIR OF TECHNOLOGIES FOR NEWBORN CARE IN LOW-RESOURCE SETTINGS
Newborn Essential Solutions and Technologies—Education
Technical Modules: Phototherapy Light

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The authors have made every effort to check the accuracy of all information and instructions for use of any devices or equipment. As knowledge base continues to expand, readers are advised to check current product information provided by the manufacturer of each device, instrument, or piece of equipment to verify recommendations for use and/or operating instructions.

In addition, all forms, instructions, checklists, guidelines, and examples are intended as resources to be used and adapted to meet national and local health care settings’ needs and requirements.
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This series has been designed with the intent of supporting the clinical use and technical repair of technologies in newborn care units.

Newborn Essential Solutions and Technologies-Education (NEST-ED) Technical Modules provide educational support for each of the technologies included in the NEST360° bundle for newborn care. These materials are intended to strengthen locally developed neonatal and technical trainings in pre- and in-service settings. Of note, these materials are not intended to be comprehensive technical guidelines or to replace the use of device-specific user and service manuals or textbooks. They are to be used to facilitate the implementation of comprehensive newborn care, including bubble CPAP, in a resource limited setting.

The NEST-ED Technical Modules were developed through a combination of international standard review, international expert feedback, and multinational NEST360° expert consensus opinion. NEST-ED Modules form the backbone of all lectures, power points, job aids, and other supportive education materials supplied by NEST360°.
ABBREVIATIONS

- **bCPAP**: Bubble continuous positive airway pressure
- **BMET**: Biomedical Equipment Technician
- **dL**: Decilitre
- **ESD**: Electrostatic Discharge
- **FiO₂**: Increased Fractional Concentration of Oxygen
- **Fr**: French size
- **HAI**: Hospital acquired infections
- **HCWs**: Healthcare workers
- **KMC**: Kangaroo mother care
- **LBW**: Low birth weight
- **LCD**: Liquid Crystal Display
- **LED**: Light Emitting Diode
- **mm Hg**: Millimeters of mercury
- **NEST-ED**: Newborn Essential Solutions & Technologies-Education
- **NEST360°**: Newborn Essential Solutions & Technologies
- **nm**: Nanometer
- **O₂**: Oxygen
- **OGT**: Orogastric tube
- **PCB**: Printed Circuit Board
- **ppm**: Parts per million
- **ROP**: Retinopathy of Prematurity
- **PSA**: Pressure Swing Adsorption
- **PSU**: Power Supply Unit
- **SpO₂**: Peripheral blood oxygen saturation
- **UPS**: Uninterruptible power supply
- **WASH**: Water, sanitation and hygiene

NOMENCLATURE

- **Allen keys**: Hex keys
- **bCPAP prongs**: bCPAP patient interface
- **Christmas tree adapter**: Barbed oxygen fitting, nipple and nut adapter
- **Control PCB**: Main PCB
- **Cot**: Bassinet, infant crib
- **Flat head screwdriver**: Slot head screwdriver
- **Flow splitter**: Oxygen splitter, flow meter stand
- **Glucometer**: Glucose meter
- **Hospital Acquired Infection**: Iatrogenic infection, nosocomial infection
- **Multimeter**: Digital multimeter, Avometer
- **Nasal prongs**: Oxygen catheter, oxygen cannula, oxygen prongs
- **Positive Pressure**: Positive end expiratory pressure, positive airway pressure
- **Radiant warmer**: Resuscitaire, resuscitation table
- **Star screwdriver**: Torx screwdriver
- **Suction pump**: Suction machine
Introduction

The NEST-ED Technical Modules have been prepared to help technical staff and students understand the basics of when and how to use equipment essential to newborn care. More importantly, the Technical Modules support staff in troubleshooting common issues, as well as prepare staff to repair equipment when it breaks down or malfunctions. Modules may be used by teaching institutions, to supplement current newborn care curricula, or by hospitals, clinical departments and individuals to update their knowledge and to better facilitate the effective and safe use of newborn care equipment. Modules should be used alongside device user and service manuals to provide additional context as needed.

Whilst reading this series, navigate to the Table of Contents by clicking the NEST360° logo that appears at the bottom right corner of each page: NEST360°

Every module has a similar structure with sections and subsections. The sections have similar headings and subheadings to make it easy for the user to navigate them. However, words may have different meanings for the various cadres of staff reading them and so to reduce misinterpretation, the heading titles are explained below.

The NEST-ED Technical Modules are intended as a flexible resource that hospitals and partners can adapt to their specific needs. The Technical Modules consist of generic content that can be applied to any model within a device category, coupled with model specific device images that can be exchanged for alternative images depending on the devices available at your facility. Individuals who are interested in gaining access to the editable NEST-ED Technical Modules should contact the NEST Training Materials Coordinator (Anniina Lockwood, al90@rice.edu) or the NEST Biomedical Tech Training Director (Sara Liaghati-Mobarhan, slmobarhan@rice.edu).

CLINICAL PROBLEM

This section provides useful information on the clinical application of a device that would bear relevance to the biomedical team, not only to aid in their troubleshooting, but also for user training.

ASSESSMENT

This section explains how the device works, and what kinds of patients it is useful for. This section also includes comprehensive diagrams of internal and external views of the devices, including consumables that may be used with the device. This section also contains detailed descriptions of key device components (including alarms) and includes a diagram of typical device flow (including components and how they interact with each other, electrical current and fluid movement through the device if relevant).
MANAGEMENT

This section focuses on clinical management and provides step by step directions on how to set the device up for a patient, followed by instructions on starting the patient on the device and monitoring a patient whilst on the device. This section also describes how to remove the equipment from the patient when it is no longer needed. Although a biomedical engineer or a technician will not be responsible for providing care, understanding these steps will be useful in training and when assessing the device.

INFECTION PREVENTION

This section lays out the basic infection prevention measures that should always be taken when handling equipment, followed by directions for disinfecting the equipment both during and after use. This section also describes the crucial Infection Prevention and Control steps that are particularly relevant to biomedical engineers and technicians.

COMPLICATIONS

This section explains some of the common but serious clinical complications that relate to and can arise from the use of the equipment (e.g., complications that will be seen or directly apply to the patient). Biomedical engineers’ and technicians’ understanding of potential complications for the patient is crucial to ensure patient safety. This section also describes common device complications (e.g., complications that will be seen or directly apply to the device).

CARE & MAINTENANCE

This section describes where to place equipment for use, how to safely handle devices and their consumables, whether calibration is recommended, and how to decommission the equipment. Biomedical engineers and technicians are responsible for second-line care and maintenance to ensure the equipment lasts to their potential lifetime; as such, this section also lists the necessary daily, weekly, monthly and annual preventive maintenance steps required to keep the device in good working condition. First-line care and maintenance is the responsibility of the user and is described in the NEST-ED Clinical Modules.

TROUBLESHOOTING & REPAIR

This section describes steps that should be taken when a device malfunctions and first-line troubleshooting efforts have failed to address the issue. This section describes tools and spare parts that might be required to prepare for repairs and to troubleshoot failures, and provides a list of components commonly provided with the device to ensure that all components return to the ward post-repair. Finally, this section also explains steps for testing, repairing, and replacing specific parts of the device.
REFERENCES & ALERTS

References & alert boxes are included within each module to provide clarity on areas where recommendations are governed by published standards, evidence, and/or expert opinion. This is included for the dual purpose of facilitating (1) feedback and continuous improvement of NEST-ED Technical Modules and (2) implementer review of content for incorporation in local trainings.

<table>
<thead>
<tr>
<th>? ALERT 0.0 Subject</th>
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<tbody>
<tr>
<td>QUERY ALERT BOXES appear where there may be controversy or disagreement. In these cases, alert boxes provide background to the recommendations that are made in the body of the document. Relevant documents are cited and brief explanation of reasoning for current module content provided.</td>
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<tr>
<td>RECOMMENDATION ALERT BOXES appear where there are recommendations based largely on expert opinion or consensus, or to emphasize an important element of care. Relevant documents are cited and brief explanation of reasoning for current module content provided.</td>
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</tbody>
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Jaundice Management

Phototherapy Light
1 Clinical Problem

Phototherapy lights are used exclusively within the newborn care ward for newborn patients displaying symptoms of high bilirubin levels (jaundice).

Jaundice is symptomatically shown by the yellowing of skin and whites of the eyes. Phototherapy may be considered for neonates with jaundice based on the age at which they show symptoms, measured or estimated blood bilirubin concentrations or with specific complications with which they present.

2 Assessment

Infants have a large volume of bilirubin in the bloodstream because they have a high red cell mass (haemoglobin) and rapid red blood cell breakdown in the first days of life. Unconjugated bilirubin released by red blood cell breakdown cannot be rapidly removed by a newborn’s immature liver, leading to an excess of unconjugated bilirubin and jaundice.

Phototherapy uses blue light transmitted on the patient’s skin within the wavelengths of 425 to 475 nm to break down unconjugated bilirubin to a water-soluble, non-toxic form that can be easily excreted. Phototherapy lights may be integrated into units with overhead (2.1), over- and under-body (2.2), or flexible blanket lights. (2.3) Most phototherapy units can be used in tandem with other devices (e.g., radiant warmers, incubators, and oxygen therapy).
Phototherapy lights are most effective when providing blue or green light within 425 to 475 nm via LEDs. Other types of bulbs providing blue light within 425 to 475 nm (e.g., halogen or fluorescent) are less effective for treating jaundice, have a shorter lifetime, and are not as sustainable for long term use. Halogen and fluorescent bulbs are less energy efficient than LEDs; as they lose energy in the form of heat, they may also create a potential risk for hyperthermia or evaporative water loss.\textsuperscript{3,4}

Other types of phototherapy are also used, but are typically not recommended:

- **UV lights**: not recommended for neonatal therapy due to increased melanoma risk associated with childhood UV exposure.
- **Natural sunlight**: historically used prior to wide availability of phototherapy devices; natural sunlight is not ideal due to increased challenges with temperature control of the patient and UV radiation risks.
- **Filtered sunlight**: there is emerging evidence that devices that filter sunlight, while requiring close monitoring in order to prevent temperature instability, can be used in babies > 2.2 kg in tropical climates to treat neonatal jaundice.\textsuperscript{5-8}

There are different methods to determine need for phototherapy, all of which rely on measuring or estimating the bilirubin levels in the blood. Bilirubin levels can be measured using a blood test or transcutaneous devices.\textsuperscript{9,10} Levels can also be estimated through visual assessment using the Kramer’s scale. (2.4)

![Kramer's Scale](image)

**Kramer’s Scale**

<table>
<thead>
<tr>
<th>1</th>
<th>4 - 6mg/dL</th>
<th>70 - 100 µmol/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>8 - 10mg/dL</td>
<td>130 - 170 µmol/dL</td>
</tr>
<tr>
<td>3</td>
<td>12 - 14mg/dL</td>
<td>200 - 240 µmol/dL</td>
</tr>
<tr>
<td>4</td>
<td>15 - 18mg/dL</td>
<td>250 - 310 µmol/dL</td>
</tr>
<tr>
<td>5</td>
<td>15 - 20mg/dL</td>
<td>250 - &gt;340 µmol/dL</td>
</tr>
</tbody>
</table>

2.4 Kramer’s Scale visual assessment areas.

Physical assessment for jaundice should be made in natural or white light to ensure results are accurate. Blood serum measurement of bilirubin levels is the gold standard for jaundice assessment. Both transcutaneous bilirubin and the Kramer’s scale are less accurate approximations of serum bilirubin levels, particularly after phototherapy has begun.\textsuperscript{11}

Most jaundiced patients require treatment for 24 to 48 hours, and typically do not require treatment for any longer than seven days. If jaundice persists, further investigation into the cause of the jaundice should be advised.

**HOW IT WORKS**

A phototherapy unit is a light. Phototherapy lamps emit a spectral irradiance (µW/cm\(^2\)), which is optimised when the light source is set to the recommended distance (height) from the patient. Most phototherapy lights’ output can be adjusted to a **standard** or **intensive** mode depending on patient needs:

- **Standard**: provides normal-range spectral irradiances for conventional phototherapy (25-30µW/cm\(^2\)) at recommended distance from the patient.
- **Intensive**: provides higher spectral irradiances for intensive phototherapy (30-35 µW/cm\(^2\)) at recommended distance from the patient.

Standard external and internal device components are annotated below in **Figures 2.5 and 2.6**. Components should be similar regardless of model. However, specific locations, visual setup and
component type may vary by brand and device model. Refer to service and user manuals if model in use is different from the displayed version.

2.5 External components of a phototherapy light.

2.6 Internal components of a phototherapy light.
TYPICAL DEVICE FLOW

LED Panel

LED Control PCB

Display PCB

Control Panel

LCD Display

01:15:01
HIGH INTENSITY

Lightmeter

Input Keys

Power Supply Unit (PSU)

Power Supply

Electrical Signal
MAIN COMPONENTS

The following device components should be similar regardless of model. However, specific locations, visual setup and component type may vary by brand and device model. Refer to service & user manuals if model is different from the displayed model.

On/Off button

The On/Off button is located on the control panel or at the back of the unit and turns the device on and off.

Control panel

The control panel, located in the front of the phototherapy light, includes an LCD that usually displays treatment time and mode. Some models may show intensity value indicators and total device hours (the total number of hours the light has been used).

The control panel also houses buttons to control the settings like light intensity and type selection (e.g., Standard vs Intensive mode and Therapeutic vs Examination lights).

Power Supply Unit (PSU)

The PSU is located internally within the phototherapy light. Its main function is to convert AC mains power (110 or 220 V) to lower voltage regulated DC power (typically 24 V). The basic components within a power supply are a transformer, rectifier, voltage regulator and filters.

Control PCB

The control PCB executes all operations of the machine, controls the display, interfaces with the input keys, controls the LEDs’ intensity, and sets the timer. It also monitors the system and collects errors for diagnosis and troubleshooting.

Lighting panel

The lighting panel is mounted internally and houses lightbulb or LED assemblies. These may be connected in series or parallel depending on the model. The lighting panel emits blue light (425 to 475 nm), which is the appropriate wavelength to break down excess bilirubin in the bloodstream.

Lightmeter

The lightmeter may be a separate measurement device or attached to phototherapy light. The lightmeter is typically a simple device, with a digital readout and photosensor to measure effective 425 to 475 nm irradiance delivered in µW/cm²/nm. A lightmeter (if available) should always be used to ensure the phototherapy light is providing therapeutic levels of irradiance. (Alert 2.1) If irradiance is low, the phototherapy light will not effectively lower patient bilirubin levels.
Management covers how to use the phototherapy light, including set up for a patient, patient commencement, care whilst on the device, and removal of the patient from the device. These instructions are helpful for a biomedical engineer or technician both in user training and in assessing the appropriate functionality of the device.

**SETTING UP FOR A PATIENT**

1. Collect:
   - Phototherapy device
   - Power cable
   - Phototherapy lightmeter (if available)

2. Plug in phototherapy device. Turn on and check for blue light from the overhead light elements. Some phototherapy lights may have white examination lights. In most models, if light emitting from this type of device is white, it is not therapeutic.

3. Turn on lightmeter if available. Hold lightmeter just above the mattress where the patient needing phototherapy will be placed. (3.1)

   ![3.1 Ideal lightmeter reading location.](image1)

   ![3.2 Adjust height if necessary.](image2)
The phototherapy unit is typically set so the overhead lights are approximately 30 – 40 cm above the cot. Light should cover the entire surface where the patient will be treated. Check that irradiance provided at this height is within therapeutic ranges; adjust height up or down if necessary. \( 3.2 \)

- If irradiance is too low, lower the height of the light until therapeutic ranges are reached without obstructing care. If there is less than 15 cm between the light and the patient to reach therapeutic levels, the device should be removed for maintenance.
- If irradiance is too high, raise the height of the light until therapeutic ranges are reached.

**PREPARING A PATIENT**

1. Clinical or nursing staff or guardian should remove all the patient’s clothes, leaving the diaper to cover the minimum necessary to keep the baby clean.

2. An eye mask should be placed so that it fully covers the patient’s eyes. \( 3.3 \) The mask should be tight enough that it will remain in place should the patient be active, but not so tight that it is visibly uncomfortable or cutting into the patient’s skin. If a ready-made eye mask is not available, ward staff may use gauze to cover the eyes and tape to secure. Avoid putting tape on the eyebrows and hair.

**STARTING A PATIENT**

1. Ward staff should place the patient directly under phototherapy lights that are switched on in a prepared cot or warming device \( 3.3 \) and the date and time of phototherapy initiation documented.
CARING FOR A PATIENT

1 Ward staff should monitor vital signs (especially temperature), skin rotation, daily bilirubin levels, signs of dehydration, and daily weight every 4 hours. **Phototherapy lights are not heaters.** Any heat provided by the phototherapy light is minimal. If the baby’s temperature lowers, they should be initiated on thermal support whilst maintaining phototherapy treatment.

### Alert 3.1

**Phototherapy lights are not heaters.** Any heat provided by the phototherapy light is minimal and due to energy loss from the efficiency of the lighting assemblies within the unit. This heat emission is not typically strong enough to provide sufficient heat to prevent a neonatal patient from becoming hypothermic. Although visually similar to radiant warmers, the purpose of the phototherapy light is solely to provide therapeutic light to treat jaundice.

2 At every monitoring point, they should also confirm that:

- The eye mask fully covers the patient’s eyes and is still secure. **(Alert 3.2)**
- The baby is feeding well and weight is not decreasing.
- There are no abnormal movements and any underlying conditions are being treated.
- Serum bilirubin levels or jaundice areas are not increasing. **Blue lights must be switched off to accurately assess visible jaundice.** Some phototherapy lights may have white examination lights that can be used to better assess the patient.

### Alert 3.2

When feeding and not under the blue light, ward staff should remove the patient’s eye mask and check for any signs of infection. The baby can be swaddled, removed from the phototherapy unit and fed in mother’s arms to facilitate mother-child bonding.

REMOVING A PATIENT

1 Turn off the phototherapy light. Gently remove the eye covering from the patient and discard. **(3.5)**

![Image of a baby being cared for](image)

3.5 Gently remove and dispose of eye covering.
4 Infection Prevention

Routine and adequate cleaning of medical devices is critical to prevent hospital-acquired infections in newborn care units.

CLINICAL INFECTION PREVENTION

1. Clean hands with soap and water or 70% alcohol before and after placing a patient under phototherapy or handling any materials that will be used on a patient (e.g., eye covers).

2. Ensure that all patient-related equipment (including eye coverings) are new or have been cleaned thoroughly before use. Any patient-related materials, including cot linen, must be cleaned before they are placed on a patient under a phototherapy device.

3. All patient-related equipment should be stored in a clean, dry location. Any cables should be loosely wrapped and secured, preventing sharp bends or kinks, which will decrease the lifetime of the cables. Do not pinch or bend the cables.

4. Only one baby should be under each phototherapy unit at any time. **Sharing a phototherapy light in one cot poses a high risk for infection transmission between patients.** Some phototherapy units may be able to provide therapeutic light to multiple patients in several cots at once; this inevitably means that cots are close to each other and increases the likelihood of infection transmission.

DISINFECTION AFTER USE

1. Turn off phototherapy light and unplug. Disinfect handle of phototherapy lightmeter and LCD controls using alcohol. **(Alert 4.1)**

2. Housing of the phototherapy unit (including the casing on the LEDs or lightbulbs) should be cleaned thoroughly according to ward guidelines for disinfecting surfaces.

BMET INFECTION PREVENTION

1. Any piece of equipment used in providing patient care must be handled carefully, as it may be contaminated and have the potential to spread infection.

2. Clean and disinfect phototherapy light housing and components whilst wearing PPE as appropriate (e.g., rubber gloves, apron, face protection, etc.) **before any repairs or maintenance are made.** **(Alert 4.1)**

3. Avoid any contact between used piece of equipment and skin, mucosa or clothing.
4 Post-maintenance, decontaminate all tools and surfaces used with 70% alcohol or according to manufacturer guidelines. Do not use equipment until it has fully dried following decontamination.

### Alert 4.1 Disinfecting Equipment

Disinfection of equipment should always comply with manufacturer guidelines. WHO recommends 0.5% dilution of chlorine (0.5% or > 100ppm available sodium hypochlorite) as the standard disinfectant for materials and surfaces contaminated by blood or body fluids.¹² For metal and rubber surfaces, which may be corroded by chlorine, 70% alcohol is also commonly utilised for low level disinfection.

Other appropriate low-level disinfectants include quaternary ammonium, improved hydrogen peroxide and iodophor germicidal detergent.¹³ Phenolic germicidal detergent is also listed in this category but should not be used in neonatal wards since affordable, effective alternatives are available; and, there are concerns it may cause hyperbilirubinemia and/or neurotoxicity in neonates.¹⁴

Please see dedicated NEST module on Infection Prevention and Control for further details on risks, benefits and utilisation of chemical disinfectants. For comprehensive guidance on infection prevention and control we recommend utilising Reference Manual for Health Care Facilities with Limited Resources Infection Prevention and Control (Caston-Gaa & Ruparelia, 2018).

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## 5 Complications

Equipment in newborn care units are highly specialised. Without proper knowledge and skills, this equipment can be potentially dangerous for the infants, families and care providers.

### CLINICAL COMPLICATIONS

- **Dehydration:** neonatal patients under phototherapy with lights other than LEDs may require more fluid than maintenance volumes.¹⁵
- **Hypo- or hyperthermia:** temperature should be carefully monitored as patients are nearly naked under phototherapy. Phototherapy devices are not intended to be heating devices. LED bulbs used in modern devices are very efficient and generate minimal heat; thermal support may be required to avoid hypothermia. Fluorescent or halogen bulbs may generate some heat through energy loss, which should be monitored to prevent hyperthermia.
- **Retinal damage:** consistent exposure of the eyes to strong light has been shown to cause retinal damage in adults. Although this has not been tested in neonates, care should be taken to keep the eyes covered at all times during treatment. (5.1)
Technical Education Modules
Jaundice Management – Phototherapy Light (Phoenix Brilliance Pro)

5.1 Uncovered eyes during phototherapy can lead to retinal damage.

- **Eye coverings:** eye coverings have the potential for several areas of complication.
  - **Attachment:** if eye coverings are too tight, they may uncomfortably constrict the patient’s head or even lead to intracranial bleeding. If eye coverings are secured using ties or strings, care should be taken to make sure the fit is comfortable and ties are not in an area that could put the patient at risk of strangulation.
  - **Eye infections:** eye coverings are kept on the patient for the duration of phototherapy treatment. Eyes should be checked regularly for redness, swelling or discharge, and the skin under the eye pads should be cleaned daily with warm sterile water to prevent infection.
  - **Infection prevention:** if eye coverings are not cleaned thoroughly before use, infection can be transmitted. Care should be taken particularly for eye coverings that are marked as single-use but are reused, or improvised eye coverings (e.g., gauze).

- **Bronze baby syndrome:** some babies develop a greyish colour to their skin, urine, and plasma during phototherapy. This is self-limiting and resolves after phototherapy is stopped.¹⁰–¹⁸

- **Acute bilirubin encephalopathy (Kernicterus):** if phototherapy settings are too low or the light is nearing the end of its bulb lifetime, bilirubin may not be effectively broken down during treatment. Extremely high levels of bilirubin can cross the blood brain barrier and cause permanent brain damage. In addition to phototherapy, exchange blood transfusions are required for serious jaundice.¹⁵

**DEVICE COMPLICATIONS**

- **Inadequate light:** after a set period of use (20,000–50,000 hours, depending on manufacturer recommendations), phototherapy devices may lose their ability to provide therapeutic light. It is important to test the capacity of the phototherapy regularly to ensure that the phototherapy light is still providing a therapeutic range (25–35 µW/cm²).
6 Care & Maintenance

Biomedical engineers and technicians are responsible for second-line care and maintenance to ensure equipment lasts to their potential lifetime.

POWER SOURCE

Phototherapy units may be powered via mains or grid power with a rechargeable battery.

WARD LOCATION

Phototherapy devices are usually rolling units on caster wheels with brakes. Devices may be rolled from patient bed to patient bed as needed. Phototherapy lights may be used with other devices, such as radiant warmers, although they should be placed in such a way that they do not hinder or obstruct care. (6.1)

DEVICE CALIBRATION

Manufacturers do not typically recommend calibration for any phototherapy light components. Phototherapy light and lightmeter components degrade over time but typically require replacement rather than calibration.

6.1 Appropriate placement for a phototherapy unit used in conjunction with a radiant warmer and oxygen splitter.
DECOMMISSIONING

Assuming appropriate use and consistent maintenance, a phototherapy light may last up to 5 years. LED light panels are intended to last the lifetime of the device and should not require replacement. Halogen or fluorescent bulbs may require replacement every 1-3000 hours or every 2-3 months until degradation. Models with these bulbs should be considered for replacement with a lower cost LED model where fiscally possible. When decommissioning a phototherapy light, intact light assemblies and circuit boards may be repurposed for other phototherapy lights or for fabricated phototherapy lights. Typically, the control PCB should only be repurposed for devices of the same manufacturer and model, although components from the circuit board may be desoldered and repurposed independently. (Alert 7.3)
## PREVENTIVE MAINTENANCE

### After Each Use
- Turn off and unplug phototherapy light. Use gauze and 70% alcohol or diluted chlorine to thoroughly wipe:
  - Phototherapy lightmeter, including cable and plug head if applicable
  - Control panel
  - Power button
  - Mattress and cot (if part of device)

See [Phototherapy Light: Disinfection After Use](#) and [Alert 4.1](#) for more information.

- Visually inspect phototherapy light components.

### Weekly
- Document cumulative hours run and preventive maintenance actions taken.
- Test the therapeutic irradiance of the phototherapy light:
  - Plug in phototherapy device. Turn on and check for blue light from the overhead light elements. NOTE: Some phototherapy lights may have white examination lights. In most models, if light emitting from this type of device is white, it is not therapeutic. Check the device manual or research the device to determine if the device is meant for phototherapy.
  - Turn on lightmeter if available. Read the irradiance in Standard Brilliance mode at 40 cm.

### Monthly
- Perform Weekly preventive maintenance steps.
- Check the caster wheels for proper movement and brake functions.
- Document cumulative running hours and preventive maintenance actions taken.

### Quarterly
- Perform Monthly preventive maintenance steps.
- Measure grounding integrity and earth and casing leakage current.
- Document cumulative running hours and preventive maintenance actions taken.

### Annually
- Perform Quarterly preventive maintenance steps.
- Confirm supply of spare power supply units, lightmeters, control PCBs, LEDs and power cables are adequate to support estimated replacement for next year.
- Document cumulative running hours and preventive maintenance actions taken.
# Troubleshooting & Repair

Biomedical engineers & technicians are responsible for providing rapid maintenance, troubleshooting & repair support for users.

## PREPARE FOR REPAIR

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<th>ACCESSIBLE TOOLS</th>
<th>SPARE PARTS</th>
<th>DEVICE CHECKLIST</th>
</tr>
</thead>
<tbody>
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<td>Digital multimeter</td>
<td>Power supply unit</td>
<td>□ Phototherapy light</td>
</tr>
<tr>
<td>Phillips, star &amp; flat head screw drivers</td>
<td>Power cable</td>
<td>□ Power cable (if detachable)</td>
</tr>
<tr>
<td>Allen keys</td>
<td>Control PCB</td>
<td>□ Lightmeter</td>
</tr>
<tr>
<td>Adjustable wrench</td>
<td>Lighting panel / assembly</td>
<td></td>
</tr>
<tr>
<td>Needle nose pliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wire strippers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase tester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightmeter</td>
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</tr>
</tbody>
</table>

## TROUBLESHOOTING FAILURES

### The phototherapy light is not turning on.

**Probable Cause:** Faulty power supply

**Components to Check:**
- Power cable continuity
- Power switch physical integrity & continuity
- Power entry module fuse(s) physical integrity & continuity
- Power supply unit continuity & voltage

### The phototherapy light turns on but light intensity will not change.

**Probable Cause:** Faulty key or wiring

**Components to Check:**
- Membrane or LCD key physical integrity & continuity
- Control PCB & associated wiring / component continuity

### The phototherapy light turns on, but only some of the bulbs are alight.

**Probable Cause:** Burnt out light assembly

**Components to Check:**
- Irradiance delivery
- Light assembly physical integrity & continuity
- Light mode
REPAIR & REPLACE

Where technically possible and not likely to obstruct clinical care, repairs may be made within the newborn care ward. Use discretion to determine if this is appropriate or if the device should be removed to the biomedical workshop for more testing or repair. **(Alert 7.1)**

**Alert 7.1**

All testing, repair and replacement steps should be conducted with the power to the device switched off and the power cable removed from mains power, unless otherwise stated.

### Testing & replacing the power supply fuses

Fuses may be located both on the phototherapy light housing and on the power supply cable. **(7.1, 7.2)** Fuse integrity may be visually assessed or evaluated by testing the continuity across the fuse. Always refer to the manufacturer specifications for replacement fuses to ensure that the device remains electrically sound in standard operation.

7.1 Assess the housing for fuses.

7.2 Open the fuse drawer and inspect the fuses. Test with a multimeter.

### Testing & replacing the power switch

Power switches should be tested in both the off and on positions to confirm functionality. In the **On** position, the switch terminals should be continuous. In the **Off** position, the switch terminals should show a high resistance, or **OL** in most multimeters. **(7.3 – 7.5)**

If the switch shows continuity or discontinuity inappropriately, assess the switch for visible physical or electrical damage. If the switch is visibly damaged or dislodged, assess whether the part can be repaired with glue or solder. If it cannot be easily repaired, replace the switch. Always refer to the manufacturer specifications for replacement switches to ensure that the device remains electrically sound in standard operation.
Testing & replacing the power supply unit or module

Testing the power supply unit cannot be completed appropriately without checking the alternating voltage at the power supply unit. (7.6, 7.7) This should be completed with caution, as the power to the device must be switched on to accurately measure the voltage delivered. If the power supply unit or module is damaged, contact the manufacturer to request a replacement part.

Testing & replacing the control panel membrane keys

Open the device and visually assess the membrane key or keys for damaged components. Verify the continuity across the membrane key. If the membrane key is not continuous, replace the key or display panel as needed.
Testing & replacing control PCB and associated components

In most cases, if one element of the control PCB has malfunctioned, the entire control PCB should be replaced. Visually assess the PCB for burnt or damaged components. *(7.8, 7.9)* Internal wiring continuity leading from the power supply to the control PCB and from the control PCB to the lighting assemblies may also be assessed for replacement. *(Alert 7.2)*

7.8 Check that components are securely connected to the PCBs.

7.9 Gently disconnect wiring and replace PCBs as needed.

**Alert 7.2**

Printed Circuit Boards (PCBs) contain components that are sensitive to electrostatic discharge (ESD) and can damage the board if not handled properly. As when handling any ESD-sensitive PCB, observe standard ESD safety procedures.

Testing & replacing the lighting panel or assemblies

If the irradiance delivered by the phototherapy light assemblies at a standard height (20 to 40 cm from the treatment location) is low, the lighting panels may need replacement. Lighting panels may be replaced in full or bulb/LED assemblies replaced individually. *(7.10)* Physical damage to the lighting panel should also be assessed and the entire panel replaced as needed.
7.10 Desolder and replace treatment LED assemblies as needed.

**Alert 7.3 Repurposing Parts**

In some cases, parts on the phototherapy unit may be replaced with a repurposed or recycled part from another piece of equipment being used for parts. **Repurposed parts should be considered with caution and guidance from the manufacturer to ensure specifications of the repurposed part are compatible with the equipment.** This includes probes and accessories that may not be compatible with multiple systems.
8 References

12. World Health Organization, Regional Office for the Western Pacific, World Health Organization, & Regional Office for South-East Asia. Practical guidelines for infection control in health care facilities. (World Health Organization, Regional Office for Western Pacific ; World Health Organization, Regional Office for South-East Asia, 2004).