

Local Guideline



Thermoregulation of the neonate in NICU

Sites where Local Guideline applies	Neonatal Intensive care Unit.JHCH
Target audience:	All neonatal clinical staff, who provide care to neonatal patients
Description	This guideline describes the management of a neonate to maintain a neutral thermal environment.
This Local Guideline applies to:	
1. Adults	No
2. Children up to 16 years	No
3. Neonates – less than 29 days	Yes
Keywords	Conduction, convection, evaporation, hypothermia, low birth weight infant (LBW), radiation
Replaces Existing Local Guideline and Procedure	Yes
Registration Number(s) and/or name and of Superseded Documents	Neonatal Thermoregulation of the baby in NICU 5 – 3. 2
Related Legislation, Australian Standards, NSW Health Policy Directive, NSQHS Standard/EquiP Criterion and/or other, HNE Health Documents, Professional Guidelines, Codes of Practice or Ethics:	
<ul style="list-style-type: none"> NSW Health Policy PD 2008_027 Maternity-Clinical care and resuscitation of the Newborn Infant http://www0.health.nsw.gov.au/policies/pd/2008/pdf/PD2008_027.pdf NSW Health Policy Directive 2007_079 Australian Resuscitation Council 2010. Guideline 13.1 Introduction to resuscitation of the newborn infant http://resus.org.au/download/section_13/guideline-13-1dec10.pdf Clinical Procedure Safety http://www0.health.nsw.gov.au/policies/pd/2014/pdf/PD2014_036.pdf NSW Health Policy PD 2005_406 Consent to Medical Treatment http://www.health.nsw.gov.au/policies/PD/2005/pdf/PD2005_406.pdf NSW Health Policy Directive PD 2007_036 Infection Control Policy http://www.health.nsw.gov.au/policies/pd/2007/pdf/PD2007_036.pdf Kaleidoscope NICU Clinical Practice Guideline "Kangaroo Care in NICU" CPG JHCH NICU 06.04 Kaleidoscope NICU Clinical Practice Guideline "Admission of babies to NICU, HDU and SCN" CPG JHCH NICU 01.01 Kaleidoscope NICU Clinical Practice Guideline "Skincare Guidelines for babies in NICU" CPG JHCH NICU 03.05 Kaleidoscope NICU Clinical Practice Guideline "Giraffe Incubator in NICU" CPG JHCH NICU 04.01 Kaleidoscope NICU Clinical Practice Guideline "Developmental care principles in NICU" CPG JHCH NICU 06.01 	
Prerequisites (if required)	N/A
Local Guideline Note	This document reflects what is currently regarded as safe and appropriate practice. The guideline section does not replace the need for the application of clinical judgment in respect to each individual patient but the procedure/s requires mandatory compliance . If staff believe that the procedure/s should not apply in a particular clinical situation they must seek advice from their unit manager/delegate and document the variance in the patient's health record.
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Date authorised	
This Local Guideline contains advice on therapeutics	No
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RISK STATEMENT

This local guideline has been developed to provide guidance to clinical staff in NICU to assist in assessment and management of thermoregulation in the newborn. It ensures that the risks of harm to the infants whilst caring for an infant being assessed and managed for thermoregulation are identified and managed.

Any unplanned event resulting in, or with the potential for injury, damage or other loss to infants/staff/family as a result of this management must be reported through the Incident Information management System and managed in accordance with the Ministry of Health Policy Directive: Incident management PD2007_061. This would include unintended injury that results in disability, death or prolonged hospital stay.

RISK CATEGORY: *Clinical Care & Patient Safety*

OUTCOMES

1	Reduce risk of infant Morbidity & Mortality secondary to cold stress
2	Successfully support newborn transition

ABBREVIATIONS & GLOSSARY

Abbreviation/Word	Definition
NICU	Neonatal Intensive care Unit
NTZ	Neutral Thermal Zone
TEWL	Trans Epidermal Water Loss
VLBW	Very Low Birth Weight

Thermoregulation of the Neonate in NICU- One Page Summary and Checklist

(Ctrl+Click on [Coloured words to jump to that section](#))

[*Normal temperatures and ranges*](#)

[*Effects of prolonged hypothermia*](#)

[*Effects of prolonged hyperthermia*](#)

[*Methods of Heat Loss*](#)

[*Thermogenic Response*](#)

[*Trans Epidermal Water Loss TEWL*](#)

[*Birth/Delivery Room*](#)

[*Nursery Admission*](#)

[*Nursing care of an Infant in an Incubator*](#)

[*Nursing care of an infant requiring humidity*](#)

[*Nursing care of an infant in an Open care System*](#)

[*Grading from an Incubator to a Cot*](#)

[*Procedures*](#)

[*Phototherapy*](#)

[*Developmental Care*](#)

[*Cold Stress Infants*](#)

[*Occupational Health & Safety*](#)

[*References*](#)

GUIDELINE

This Guideline does not replace the need for the application of clinical judgment in respect to each individual patient.

Rationale

Survival of very low birth weight (VLBW) infants has been shown to be effected by alterations in thermoregulation. Morbidity and mortality of preterm infants remains greater than other newborn infants because of their innate vulnerability and environmental factors they are exposed to ^{1,2,3,4,19}. Maintaining a thermo-neutral environment is essential for the survival of newly born premature infants ^{1,2,3,4,18,19}.

Normal temperature[Top](#)

Thermoregulation is the ability to balance between heat production and heat loss in order to maintain body temperature within a normal range ^{1,2,5}.

Temperatures are recorded per axilla. Although temperatures are individualised the World Health Organization² identifies the normal range for neonates as 36.5-37.5^oC Celsius (C). In studies of 'normal' temperature of newborns the mean axillary temperature required to maintain minimal calorie consumption was 36.5^oC².

Temperature ranges ^{2,19,20.}[Top](#)

>37.5^oC - Hyperthermia

36.5-37.5^oC – **Normal range**

36.0-36.5^oC - Mild hypothermia (potential cold stress)

32.0-36.0^oC - Moderate hypothermia

<32.0^oC - Severe hypothermia

Effects of prolonged hypothermia ^{2,5,6}[Top](#)

- Reduced surfactant production
- increased oxygen consumption
- respiratory distress
- apnoea and bradycardia
- metabolic acidosis
- hypoxia
- renal dysfunction
- cardiac dysfunction
- static weight or weight loss
- poor organ growth
- abdominal distension
- vomiting
- dissociation of haemoglobin
- coagulopathy
- brain damage
- death

Effects of prolonged hyperthermia ^{2,5,6}[Top](#)

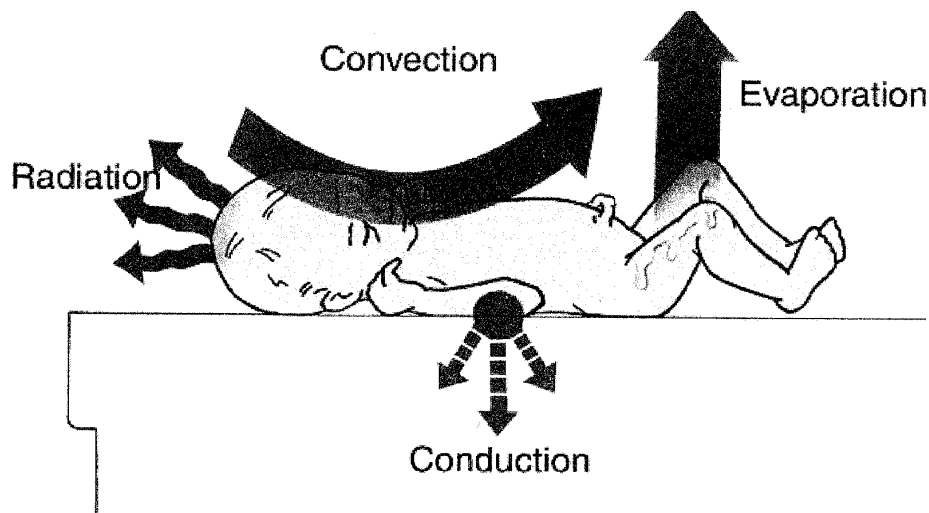
- Poor feeding
- tachycardia
- tachypnoea

- irritability
- hypotonia
- lethargy
- increased oxygen consumption
- static weight or weight loss
- brain damage
- death.

Methods of heat loss^{1,2,5,6}

[Top](#)

- **Evaporation**-occurs when fluid evaporates from wet skin. Evaporation increases when the baby is under a radiant warmer.
- **Conduction**-occurs when skin comes into direct contact with a cooler surface.
- **Radiation**- occurs when heat is radiated to cooler objects surrounding the infant although there is no skin contact.
- **Convection**- occurs when the air surrounding the infant is lower than body temperature.



Mechanisms of Heat Loss²

Thermogenic response^{2,7}

[Top](#)

Thermogenic response begins within minutes of birth.

There are three heat production modalities;

- 1) Increased metabolic activity¹⁸.
- 2) Peripheral vasoconstriction is one of the body's mechanisms to diminish heat loss; preterm infants however have poor vasomotor control limiting their ability to control vasoconstriction for heat regulation¹⁹.
- 3) Non-shivering and shivering thermogenesis.
 - a. Shivering thermogenesis is not significant due to the immature neonatal muscles therefore no response in temperature control is seen in infants^{18,19,20} (term babies will shiver at temperatures of 32-34°C and lower).
 - b. Non-shivering thermogenesis is the primary heat source in neonates. It is brown adipose tissue dependant. Between 26 to 30 weeks gestation brown adipose tissues begins to be deposited around the scapulae, kidneys, adrenals, neck and axillae. This tissue metabolises to produce heat in babies greater than 28 weeks gestation and is rapidly depleted when cold stress occurs²¹.

Transepidermal water loss (TEWL)

[Top](#)

TEWL refers to the insensible water lost from the skin and is inversely related to gestational age and the degree of maturity of the epidermal stratum corneum.²⁶ The incidence of TEWL is greater in infants less than 27 weeks because they have not yet formed the outer protective layer of their skin, the stratum corneum, and also because they have a large surface area to weight ratio.^{5, 6}

Skin is permeable and incapable of retaining water. Heat can be lost into the environment through various mechanisms, including evaporation via the skin.²³ as well as the membrane linings of the respiratory tract. This mode of heat transfer is the biggest cause of heat loss in preterm infants in the first week of life.²⁴

Humidified gases and humidified environments aid in reducing TEWL.⁸ Radiant heat has been demonstrated to increase TEWL,⁸ however the use of polyethylene wrap now counteracts this loss in infants 30 weeks and under^{18,19,20}. See [“Skincare Guidelines for babies in NICU” CPG JHCH NICU 03.05](#)

Premature infants are at significant risk of cold stress and trans epidermal water loss (TEWL). Cold stress impacts on both oxygenation and metabolism significantly effecting successful transition to extra-uterine life.²⁵

The reduction of TEWL is important to both improve temperature control and significantly reduce electrolyte and fluid balance abnormalities.²⁷

It is known that an environment of high-saturated humidity will suppress evaporation from the skin²⁷ and that the use of humidified incubators can significantly reduce the amount of TEWL in premature infants in the first week of life.⁷

It has also been shown that, despite extreme prematurity, once an infant’s skin is exposed to the extra-uterine environment, it will rapidly mature, resulting in a more effective skin barrier to TEWL.²⁸ Therefore, after this time maintaining the infant in a highly humidified environment can potentially hinder maturation and development of the stratum corneum and therefore prolong increased rates of TEWL.^{20, 28}

Birth/In the delivery room-

[Top](#)

Although this guideline is written for NICU the environment at birth is important. NICU staff must be aware of the following:

The neonate is particularly vulnerable to thermal stress due to immature or absent thermoregulatory mechanisms, increased heat loss and large body surface area in relation to body mass^{1, 2}. At birth heat exchange through the placenta is lost and the infant moves from the warmth of the mother to the external environment, leaving the baby exposed to thermal stress^{2,4}. It is important to follow the warm chain to help to reduce the effects of thermal stress and maintain a neutral thermal environment.

The warm chain is consideration of the following: warm delivery room, immediate drying (in term infants only), skin to skin contact, breast feeding, bathing/weighting postponed, appropriate clothing

and bedding, mother and baby together, warm transportation, warm resuscitation and awareness training^{2, 5,6}.

Although less common, environmental hyperthermia is equally as dangerous².

- The environment at delivery should be aiming to provide a neutral thermal environment- the ideal temperature at which the infant is maintaining temperature with minimal oxygen consumption^{2, 4}.
- The delivery room temperature should be at least 25°C².
- **The term infant** should be dried with warm towels and warmed with all wet linen removed².
- **Preterm infants** < 30 weeks gestation should not be dried but covered in an occlusive polyethylene wrap to reduce insensible water loss and hypothermia^{9, 10,11,12,13,14,18,19,20}; they should be transported in a warm environment to the Neonatal Intensive Care Unit.
- Hats- heat exchange between the head and the environment is very high. Whilst a hat alone has not shown a great benefit in reducing heat loss, a hat covering over the polyethylene wrap reduces heat loss in VLBW by up to 70%¹⁹
- For babies who do not require resuscitation at birth skin to skin care with the mother is the best mode of providing a thermo-neutral environment^{2, 4} See "[Kangaroo Care in NICU](#)" CPG [JHCH NICU 06.04](#)

Nursery admission

[Top](#)

Assess the axilla temperature whilst the infant is on the resuscitaire from Delivery suite/Operating theatres. Then place a warmed cloth on the weigh scales, weigh infant quickly then place in a pre-warmed "admission bed". If admitting the baby to a Giraffe bed the weight can be done in the cot- see below. See also "[Admission of babies to NICU, HDU and SCN](#)" CPG [JHCH NICU 01.01](#)

Admission bed- is defined as one of several types of bed used to care for neonates depending on their gestational age and weight and is usually one of the following: Open care bed, Giraffe Omnibed, Hillrom Airshield C2000/ C200/ C100/ Draegar C2000. All apart from the open care bed are known as incubators. A baby can be admitted to the nursery in an open cot if they are term and normothermic. See "[Giraffe Incubator in NICU](#)" CPG [JHCH NICU 04.01](#)

It is important for thermoregulation of the infant to wrap in cling wrap at delivery and keep this insitu until humidity commences; refer to CPG 5. 1. 16b "Resuscitation of the Preterm infant in NICU"

Humidity should be commenced in the first few hours of admission for infants <30 weeks, following stabilisation of ventilation and line insertion -. see [Nursing Care of an Infant requiring Humidity](#)

Incubator

Preterm infants' heat production is restricted due to their limited supplies of brown fat and glycogen stores, which are quickly utilised if the infant becomes hypothermic^{1, 2}. Maintaining a thermo-neutral environment favourably influences the survival of premature infants^{1,2,3,8,15}. Thus during the first week(s) of life low birth-weight infants should be provided with a carefully regulated thermal environment^{2, 15}.

Nursing care of an infant in an incubator

[Top](#)

- Be aware of all methods of heat loss and follow guidelines for the warm chain.
- The Neutral Thermal Zone (NTZ) is a guide for isolette temperature setting (to minimize oxygen and energy consumption) for minimal calorific usage in maintaining normothermia. This guide is based on the naked infant and is available in both nurseries. The NTZ should be used as a guide and recorded on the daily observation sheet of all infants nursed in incubators.
- If an infant requires observation of respiratory effort nurse with a nappy only (photo1)



Photo 1

- If the infant is dressed ensure the clothing is pre-warmed prior to changing and clothing on the infant is not left wet. Remove any wet linen from the infant immediately.
- Do not block the circulated flow of heat from the incubator. No equipment should be left at either end inside the isolette. No toys should be left inside the incubator.
- Skin control with a temperature probe attached is preferred if the infant is undergoing a procedure, [See page 9 for positioning probe](#) & [“Giraffe Incubator in NICU” CPG JHCH NICU 04.01](#). This will ensure that although the isolette is open the infant will not lose heat.
- Air temperature control is the usual everyday method of control of the infant’s environment.
- All infants in incubators should be monitored either by electro cardiac monitor or oxygen saturation monitor and this should be recorded hourly.
- **Attending to cares** - Cares should be attended to either three, fourth or sixth hourly depending on the infant’s condition and the timing of gastric feeding. When attending to cares the axilla temperature should be recorded first as to attain the most accurate recording. Ensure that cares are not prolonged thus reducing the capacity of the incubator to maintain normothermia. The temperature of the incubator should be recorded hourly and the appropriate NTZ documented daily.
- **Bathing/ sponging**- Infants in incubators are not immersed in water due to their incapacity to maintain normothermia –instead they are sponged and dried in small sections within the isolette. For example the face and head are washed and dried before the arms and trunk of the body. Clothing and bedding that is changed is pre-warmed to ensure a reduction in heat loss. See” [Skincare Guidelines for babies in NICU” CPG JHCH NICU 03.05](#)

Nursing care of an infant requiring humidity

[Top](#)

Humidity should start at **85%**. Greater than 85% results in excess rainout and temperature instability.²²

Humidity should be reduced with respect to gestation and temperature stability, as outlined below.

Infants of 28-30 week gestation: If temperature is stable after 24 hours humidity can be reduced by 5% each day.

Infants < 28 weeks gestation: Maintain humidity at 85% for the first 7 days of life, and then reduce by 5% daily if temperature stability allows.²²

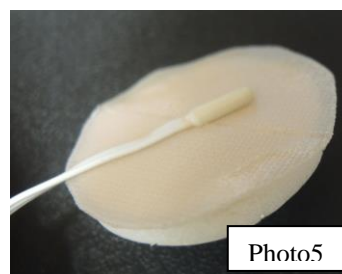
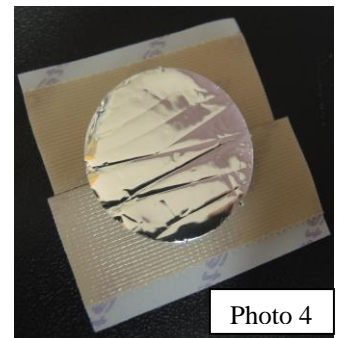
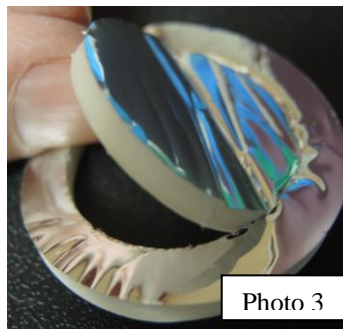
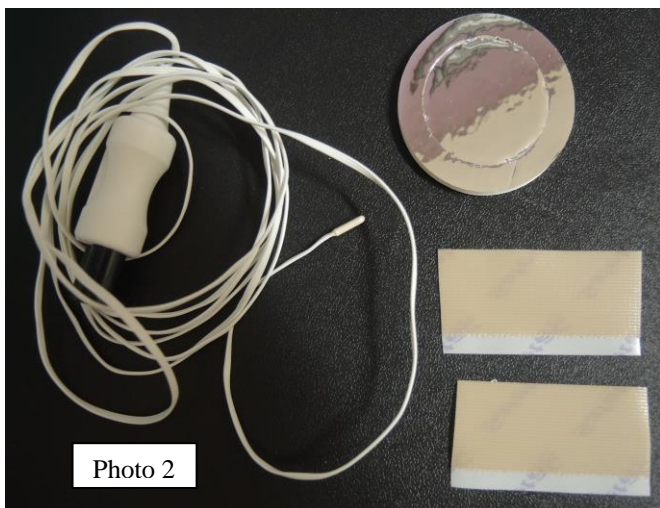
- Humidity should be discontinued when a level of 50% is reached and temperature stability allows. However it is ultimately at the discretion of the neonatologist when the infant is to be completely removed from humidity.
- If initially required, reduce environmental temperature rather than level of humidity. Ambient temperature is usually around 36.5 degrees in the first three days of life.²²
- In order to reduce rain out in the incubator, place a cover and bubble wrap over the incubator.
- Ensure the bubble wrap is bubble side down to trap air.
- Record humidity level hourly on observation flow chart.
- Infants < 28 weeks gestation in the first week of life, and nursed in humidity will require consultation with the Neonatologist regarding the suitability for Kangaroo Care-refer to CPG 5. 9. 1 “Kangaroo Care in NICU”
- Check water level regularly and refill with distilled sterile water as required or when crib alarms.
- Infants in humidified incubator can be nursed on a large burn pad or Zetuvit™ pad to maintain skin integrity.
- To prevent microbial build up the water tray should be completely removed when routinely changing incubator each week or when humidity ceases. This is attended to by the Technical Assistants who will soak, clean and replace the tray.²²

Nursing care of an infant in an open care system

see “[Giraffe Incubator in NICU](#)” CPG JHCH NICU 04.01

[Top](#)

- If an infant is being nursed on an open care system or the Giraffe Omnibed is opened for procedures then the infant should be placed on servo control (infant’s skin temperature controls the heat output).
- The open care system / Giraffe Omnibed temperature probe is applied to the infant with Mepitac® and a reflective disk. The probe is best placed in the mid axillary line, below the arm pit, i.e.; side of infant just below armpit to ensure flat area (Recommendation from Ohmeda™-manufacturers of Giraffe Omnibed)²⁹. Refer to photos 2,3,4,5 & 6 below for equipment required and placement of temp probe.





- **Ensure the temp probe lies between the skin and Mepitac tape which is adhered to the reflective disc for accurate measurement of temperature (photo 5)**
- A smaller disc can be made by removing outer ring of reflective disc for smaller infants and this can be cut even smaller for the ELBW neonate (see photo 4)
- This also enables repositioning the infant between supine and prone position without removal of the probe.
- Careful attention must be undertaken to prevent hypo or hyperthermia if using this form of temperature control as there is a risk of the Mepitac[®] and reflective disk lifting.
- If an infant is having a procedure such as insertion of a central line extra care must be taken to ensure there is no interference with the servo-control of the infant's temperature and regular axilla temperatures should be taken.
- The servo probe should be repositioned at least on a daily basis to reduce the risk of pressure marks occurring.

Grading from incubator to cot ^{16, 17, 18}

[Top](#)

The time to grade from incubator to open cot depends on the infant's skin thickness and thus how many days old the infant is. Grading an infant from an incubator to a cot is considered on an individual basis. The weight for weaning on one study is 1700-1800g¹⁷ however another study found that infants could maintain normothermia and growth when weaned to an open cot at weights of 1600g¹⁸ if they managed to maintain normothermia in an incubator temperature of 30°C or less.



When the infant maintains an axilla temperature above 36.5°C , whilst lightly dressed (see photo 7) the incubator temp can be reduced by 0.5°C . Lightly dressed consists of a nappy, singlet and baby all in one or dress +/- booties. The axilla temperature is recorded with 'cares' each three or four hours and the temperature gradually reduced by 0.5°C each time if the infant's temperature is maintained at or above 36.5°C .

During the incubator grading process other criteria to consider is whether the infant demonstrates consistent weight gain (20-30grams per day), tolerance to feeds¹⁸ and handles well. A baby is considered to handle well if the vital signs are stable, the infant is alert and there is normal posture and tone during cares and procedures.

When the incubator temperature reaches 28°C , the infant can be further dressed with pre-warmed clothing (hat and cardigan), wrapped (photo 8) and covered with pre-warmed blankets and placed in an open cot (photo 9). Continue to monitor when infant is wearing a hat.

The axilla temperature should be assessed and recorded one hour later to ensure the infant has maintained an axilla temperature of 36.5°C . If the axilla temperature is not maintained return the infant to the incubator for a further 24 hours before trying to wean again. The incubator should remain pre-warmed near the infant for 12 hours in case it is required.



Photo 8

Note: Should the infant's temperature fall below 36.5°C during the 'grading' process the incubator temperature should be put up by 0.5°C . and the infant's temperature monitored hourly until a temperature of 36.5°C is attained and maintained. The crib temperature should not be put up in higher gradients than 0.5°C . as this can be the cause of increasing apnoea. The infant should not be graded from the incubator for another 24 hours.



Photo 9

Open cot

If the axilla temperature is $>37.3^{\circ}\text{C}$ remove blankets and lightly wrap the infant in a sheet. If $<36.5^{\circ}\text{C}$ apply pre-warmed blankets or provide Kangaroo care with the mother, for a minimum of one hour, and re-check axilla temperature. If the temperature continues to be $<36.5^{\circ}\text{C}$ return the infant to the incubator.

Rewarming⁵

When returned from open cot to the incubator within a 24-hour time frame the incubator temperature should be set to the infants NTZ to rewarm the infant. Axilla temperature should be

checked hourly and the incubator temperature increased in gradients of 0.5°C until normothermia reached and maintained. Keep incubator doors closed as much as possible. Please note it is important not to overheat the baby.

Procedures

[Top](#)

Record a base line axilla temperature before commencing procedures that may interfere with the incubator settings. Apply skin temperature probe and place the incubator on skin servo control, and check axilla temperature once skin temperature has stabilised to ensure accurate correlation between the two. Throughout the procedure monitor temperature readings and axilla temperature during and post procedure to ensure normothermia maintained.

Phototherapy

[Top](#)

In many incubators the addition of phototherapy lights increases the radiant heat into the incubator. In the Giraffe bed the skin control mode **must** be used and in older incubators the temperature is reduced by 0.5°C and the axilla temperature closely monitored until stable and within normal range.

Developmental care

[Top](#)

Incubators can be noisy environments Refer to the [“Developmental care principles in NICU” CPG JHCH NICU 06.01](#) for ways to reduce this noxious stimuli.

Cold stressed infants

[Top](#)

On admission the incubator temperature should be 1-1.5°C higher than the infant's axilla temperature⁵ and monitored hourly. When normothermia is reached and maintained the incubator temperature should be reduced by 0.5°C until NTZ reached to avoid hyperthermia. The axilla temperature should be recorded hourly until stable.

These infants should have their blood glucose level monitored regularly, with a regime determined by the NP/Fellow or Consultant.

Occupational, Health & Safety

[Top](#)

- Ensure safety at all times when opening incubator doors or taking the whole side down for moving the infant from the incubator.
- Ensure parents are aware of safety features of incubator.
- Take care when moving incubator, this must be done with two staff.
- Incubators should be changed every seven days to minimise the risk of infection.
- Incubators should be wiped over each shift especially along the portholes.
- Maintain a clean and dirty side of incubator. The clean side is where equipment goes in and the dirty side is where it is removed, particularly soiled nappies (which are also removed through the foot end porthole only).

References

[Top](#)

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