GUIDELINE

Thermoregulation

Scope (Staff):	Nursing and Medical Staff
Scope (Area):	NICU KEMH, NICU PCH, NETS WA

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Aim

To outline thermoregulation care for the newborn and preterm infant.

Risk

Mismanagement of thermoregulation causes thermal stress, increasing the risk of morbidity and mortality.

Background

Newborn infants are vulnerable to thermal stressors related to physiological and environmental factors. Modes of heat loss occur due to evaporation (from wet, immature skin), convection (through circulating air), conduction (direct contact with cooler surfaces) and radiation (to colder surfaces not in direct contact). Preterm infants are at greater risk of heat loss and cold stress due to a high surface area to mass ratio, immature skin (lack of subcutaneous fat and deficient keratin), poor vasomotor control, inability to generate heat (reduced brown fat stores) and naturally extended posture, exposing a greater body surface area to the external environment.

For the infant to maintain normothermia (36.5-<37.5 degress Celsius) the provision, management, and monitoring of the envirnonment is imperative. This includes regular temperature and other physiological monitoring, minimising environmental stressors and the use of thermal assistive devices.

Definitions

Cold stress – occurs when body temperature falls below the normal range leading to excess energy and oxygen consumption and complications such as hypoglycaemia and respiratory distress.

Infant Servo Control (ISC) i.e. Baby Mode – an automated system where an incubator/radiant warmer continuously adjusts its output based on feedback from the infant's skin temperature probe.

Thermal Challenging - is a gradual weaning of thermal support ie incubator, to encourage the infant to maintain a normal core temperature (36.5ºC – <37.5C).

Neutralthermal environment (NTE) – the ambient temperature range where an infant maintains a normal core temperature (36.5ºC – <37.5C) with minimal energy expenditure and oxygen consumption.

Thermoregulation – the ability to regulate core body temperature even when evinronemental temperature is variable.

Trans-epidermal water loss (**TEWL)** – passive evaporation of water vapor through the skin due to an underveloped stratum conreum allowing fluid to escape rapidly. Preterm infants have much higher TEWL than term infants due to skin immaturity.

Key Points

Neonatal Temperature Ranges

Normal range is **36.5ºC - <37.5ºC** for all infants measured per axilla (PA)

- Neonatal temperature is monitored (PA) using digital thermometers and skin temperature probes.
- An infant's core body temperature will be higher than the recorded skin temperature, with a difference of ~ 0.5ºC in term infants; the difference may be narrower in very preterm or unwell infants.

- When the temperature measured is outside normal range, review the infant to establish if the cause is endogenous or environmental, action appropriately. Avoid rapid heating and cooling. Aim to raise or lower the infant's temperature by 0.5 ºC per hour. Measure temperature 30 minutely until within normal range.

- NOTE: Skin temperature probes may be inaccurate if there is significant peripheral shutdown.

Radiant Warmer and Incubator

- Pre-warm prior to use:
  - Giraffe/Panda radiant warmer automatically enters 'warmup' mode when powered on.
    - Admission: select 'Admit Baby' then 'Baby Mode" and set temperature to 36.8 ºC
    - Birth and/or resuscitation: set radiant warmer to manual and maximum heater output
  - Incubator: set as per the Neutral Thermal Environment tables or Ominbed COMFORT ZONE
- Incubator ISC/Baby mode is to be used for all infants < 32 weeks gestation.
- Incubator Manual mode is to be used for all infants > 32 weeks gestation.
- Infants born < 32 weeks or < 1500g are placed in an incubator with **humidity until at least 2 weeks of life.** Weaning of humidity depends on gestational age. For infants <25 weeks refer to Tiny Baby Protocol Infants > 25 weeks should commence weaning after 7 days of age. Wean humidity at 5% intervals over the period of a week whilst observing incubator temperature ranges and PA temperature refer to humidity tables. Ambient humidity is 40-45%.
- Incubator humidity is provided using sterile water. Water levels are to be checked and maintained as per Omnibed™ manufacturer's instructions for use. Empty humidity reservoir once humidity ceased.
- Incubators are cleaned twice daily and changed weekly (sooner if soiled). Refer to Environmental and Equipment Cleaning.

Optimal skin temperature probe placement, securement, and monitoring:

- Apply to abdomen, axillae, back or flanks. Avoid bony areas.
- Do not place probe between the mattress and the infant to prevent false reading.
- Secure temperature probe to clean and dry skin using a reflective cover. Apply Sil-Flex™ underneath the reflective cover to improve temperature probe adherence and to protect skin integrity.
- Skin probe temperature should correlate within 0.5 ºC of PA temperature. Continuously monitor and record the skin temperature read out. Check PA

temperature every hour until stabilised then 4 hourly to ensure correlation with skin probe temperature.

Thermal Challenging

- Should take place daily once the infant's PA temperature has remained stable within normal limits (WNL).
- The incubator should **NOT** be turned off, and the portholes should **NOT** be left open. Doing so may place the infant under thermal stress and is a safety hazard.

Implications for Practice

- Preventing heat loss at birth
- Thermoregulation management during the 'Golden Hour'
- Thermoregulation challenges and considerations
- Thermoregulation management:
  - Incubator temperature and humidity management
  - Transitioning from an incubator to an open cot
  - Heated mattress management - CosyTherm

Figure 1: Preventing Heat Loss at Birth

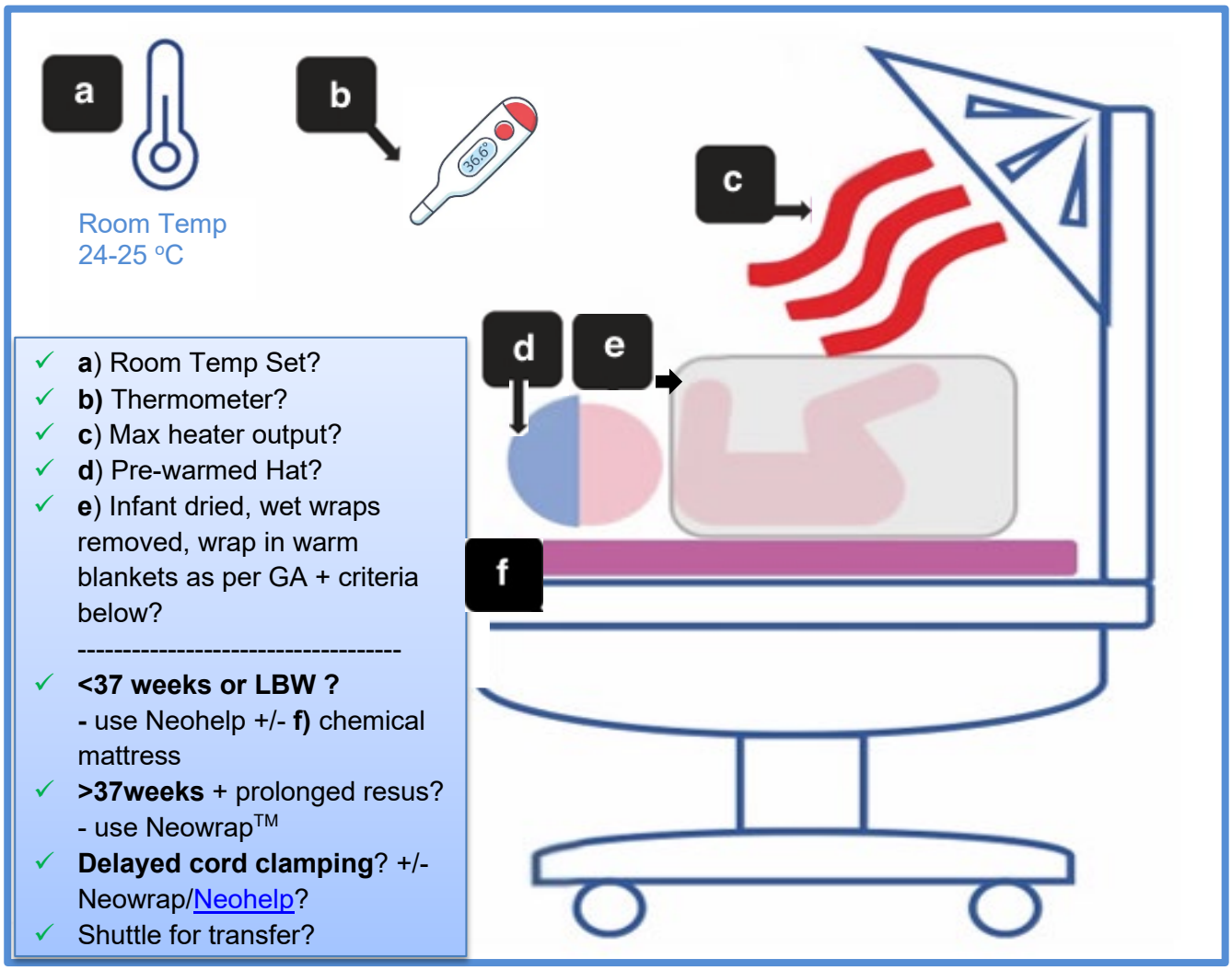

Figure 1: Adapted from graphic cited in Dunne EA, et al.

Thermoregulation Management Golden Hour

On admission, transfer infant to an Omnibed or Radiant Warmer, depending on gestation and / or acuity
Refer to Handover and Transition to the Neonatal Unit
For Infants <25 weeks refer to the Tiny Baby Protocol

<32 weeks and <1500 grams

Omnibed™ Pre warmed as per Comfort Zone
- Raised canopy (radiant warmer function)
- Apply temp probe, select 'Baby Mode'
- Set skin temp 36.8 °C
- Add (prewarmed) external humidity with preset temp humidity base and airflow 10 L/min*)
- Weigh – Omnibed scales
- Hat – pre-warmed

Close Canopy ASAP
- Select 'Baby mode'
- Set skin temp 36.8°C
- Commence humidity
  - <25 weeks refer Tiny Baby Protocol
  - <28weeks 80%
  - 28-32 weeks 70%
- Boost Air Curtain – activate when portholes open

***Direct the external humidification source towards the mattress and away from the infant's skin to decrease risk of thermal injury**

CHECK and **Document**
- PA temp
  - On admission and then hourly until within normal limits
  - 4hrly/with feeds once WNL
- Hourly
  - Skin temp probe reading
  - Omnibed air temp reading
  - Humidity % reading

>32 weeks and >1500 grams

Radiant warmer Giraffe/Panda™
- Pre-warmed (Warmup mode)
- Select 'Admit Baby'
- Apply temp probe, select 'Baby Mode'
- Set temp 36.8°C
- Weigh – radiant warmer scales
- Hat – pre-warmed

CHECK and **Document**
- PA temp
  - On admission and then hourly until within normal limits
  - 4 hrly/with feeds once WNL
- Hourly
  - Radiant warmer set temp and heater output
  - Skin temp probe reading

Transfer infant within 4 hours of Admission		
	Incubator (manual mode)	**Open Cot**
Criteria	1500g-2kg	>2kg and <30% heater output **NO** respiratory support
Clothing (pre-warmed)	top, hat, booties, not wrapped **Do NOT** dress infants with umbilical lines, poor skin integrity, phototherapy	vest, top, cardigan, hat, booties; wrap in cuddly; blanket
Pre-warmed	Temp set as per NTE tables + 2 °C	N/A
PA Temp	Check 30 mins post transfer then hourly until WNL 4hrly/with feeds once temp WNL	Check 30 mins post transfer then hourly until WNL 4hrly/with feeds once temp WNL

Maintaining the Neutral Thermal Environment

Thermoregulation challenges /considerations and transitioning out of incubator

Thermoregulation Challenges and Considerations

Medical review of the infant is required if environmental factors have been considered / adjusted and the infant's temperature remains outside normal range. Refer to Recognising and Responding to Clinical Deterioration guideline

Thermoregulation Challenges and Considerations		
	Hypothermia	**Hyperthermia**
Radiant warmer *All infants nursed on radiant warmers and incubators should wear a hat*	➢ Check skin temp probe placement, adherence, function and correlates with PA temp ➢ Clean/resite/replace skin temp probe ➢ Continuously monitor temp until WNL ➢ Consider transfer to incubator/open cot with Cosy Therm ➢ Consider Skin to Skin Holding	➢ Check skin temp probe placement, adherence and function. ➢ Correlate with PA temp ➢ Clean/resite/replace temp probe ➢ Continuously monitor temp until WNL ➢ Consider transfer to incubator/open cot
Incubator – manual mode	➢ Check NTE tables relative to age/gestation and adjust air temp ➢ Apply skin temp probe for monitoring, correlate with PA temp ➢ Increase incubator temp 0.5ºC hourly until PA temp WNL ➢ Dress lighlty and **DO NOT** swaddle	➢ Do not remove hat ➢ Reduce the incubator temp by 0.5ºC hourly until PA temp WNL ➢ Consider transitioning to open cot
Incubator - ISC/Baby mode	➢ Check PA temp correlates with skin temp probe ➢ Check skin temp probe placement, adherence and function ➢ Clean/resite/replace skin temp probe ➢ Increase humidity if < 2 weeks age. See Humidity Table ➢ Do not use plastic wraps for rewarming (procedures only)	➢ Check PA temp correlates with skin temp probe for continuous monitoring ➢ Check skin temp probe placement, adherence and function ➢ Clean/resite skin temp probe ➢ Reduce humidity by 5% and monitor for effect.
NOTE: RAINOUT IS CAUSED BY A MISMATCH BETWEEN THE HUMIDITY SET AND THE INCUBATOR TEMP. SEE HUMIDITY TABLE		
Open cot	➢ Review clothing, wraps and blanket. See Clothing and wrapping infants ➢ Monitor PA temp 30 minutely until WNL ➢ Consider rewarming under radiant warmer if above fails. Remove all clothing and wraps to rewarm. Once rewarmed consider Cosy Therm	➢ Review clothing, wraps and blanket. See Clothing and wrapping infants ➢ Monitor PA temp 30 minutely until WNL
Refer to Pre-Operative Care and Intrahospital transport of the Neonate for additional thermoregulation considerations during transfer		

Clothing and Wrapping Requirements in an Open Cot

Infant's maybe transferred to an open cot 4 hours after admission if not requiring an incubator to maintain their temperature within normal limits. Refer to thermoregulation challenges and considerations and transitioning out of the incubator

Infant's nursed in open cots are to be dressed according to individual needs.

Clothing and Wrapping Requirements	
Fully dressed includes: • Vest • Top +/- Grow suit • Cardigan • Hat • Booties • Wrap in cuddly as per SIDS guidelines • Blanket to cover	Consider reducing clothing layers as infant maintains temperature WNL. 1. Cardigan 2. Grow suit if used 3. Vest 4. Booties 5. Hat
Note: Infants in the neonatal unit are not required to be monitored (if clinically not warranted) when wearing a hat. By discharge home, infants should be able to maintain their temperature without a hat complying with Safe Infant Sleeping	

References and related external legislation, policies, and guidelines

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Related CAHS internal policies, procedures and guidelines

Admission to NICU KEMH and PCH
Environmental and Equipment Cleaning
Handover and Transition to the Neonatal Unit
Intrahospital transport of the Neonate
Pre-Operative Care
Skin to Skin Holding
Safe Infant Sleeping
Tiny Baby Protocol

This document can be made available in alternative formats on request.

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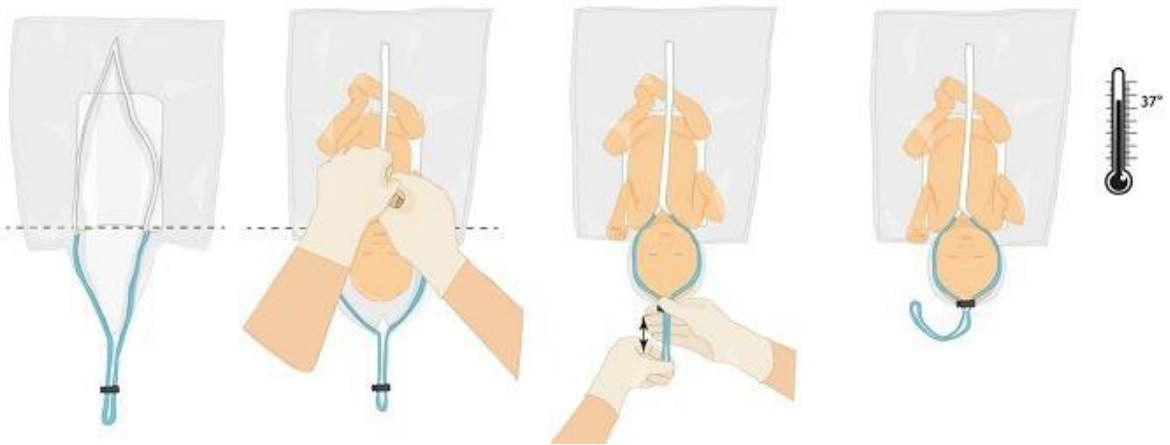
Appendix 1: Neohelp™

- Use NEOHELP™ for all infants <37 weeks or LBW
    - Sizes <1kg and 1-2.5kg available
- In theatre
    - Open Neohelp™, prepare a small hole for the right hand to apply oxygen saturation probe with sterile scissors and place the bag in the operative field to allow the infant to be placed in the bag to allow for delayed cord clamping (if baby breathing and vigorous)
        - Sizes <1kg and 1-2.5kg available.
- In delivery room
    - Open Neohelp™ and lay it down flat on the resuscitaire, prepare a small hole for the right hand to apply oxygen saturation probe then take the bag to the midwife/Obstetric delivery team so the infant can be placed in the bag during delayed cord clamping on mother's abdomen.
- Draw the string around the infant's head and close the Velcro with the umbilical cord and clamp external to the bag.
- Bring the right hand OUTSIDE the Neohelp in the small hole that has been pre-made for placement of oxygen saturation probe.
- Always transfer infant in a Neohelp™ within a blanket to avoid slipping in transfer
- If Neohelp™ unavailable the NeoWrap™ can be used with a knitted hat.



- Prior to transfer, **measure the infant's temperature and if not in the normal range address this prior to transfer**.
    - If < 36.5ºC apply chemical blanket. Place white side up and **with a blanket between** the mattress and baby. Use fresh warm blankets if not available.
- Use shuttle to transfer infant to nursery. If not available, utilise warm blankets and plug resuscitaire into power during handover. Refer to Handover and Transition to the Neonatal Unit

Appendix 2: Comfort Zone, Neutral Thermal Environment and Humidity Tables

The COMFORT ZONE

A guide to setting temperature within the Omnibed

The Comfort zone settings are accessed using the touch screen or control knob to the right of Accessory Control Panel screen.

- Based upon expected birthweight, estimated gestational age, and postnatal age (natal day = day 1), you will see a recommended *"Comfort Zone"* air temperature setting that should be used to pre-warm the closed bed.
- NOTE: Simply enter estimated weight based upon your clinical experience.
- Using the touch screen or Temperature Control Buttons, adjust the air temperature up or down to the desired temperature (in air mode).
- Exit *"Comfort Zone"*, if no touch screen - Depress control knob to return to accessory control panel screen.

Neutral Thermal Environment (NTE)

The younger the infant and/or the lower the infant's weight, the higher the temperature and humidity required**.** The below NTE table is a guide for when the Omnibed is not available or indicated and for infants nused in incubators on manual control.

Table 1: Neutral Thermal Environment For Infants Day 1 – 5 of Life				
Age	**<1200g** +/- 0.5ºC	**1201 - 1500g** +/- 0.5ºC	**1501 - 2500g** +/- 1.0ºC	**>2500g and >36wk**
0 - 12 Hours	35.0	34.0	33.3	32.8
12 - 24 Hours	34.5	33.8	32.8	32.4
24 - 96 Hours	34.5	33.5	32.3	32.0

Table 2: Neutral Thermal Environment For Infants > 5 Days Of Age			
Age	**<1500g**	**1501 - 2500g**	**>2500g and >36wk**
5 - 14 Days	33.5	32.1	32.0
2 - 3 Weeks	33.1	31.7	30.0
3 - 4 Weeks	32.6	31.4	
4 - 5 Weeks	32.0	30.9	
5 - 6 Weeks	31.4	30.4	

This data has been taken from the Royal Children's Hospital and Westmead Children's Hospital clinical guidelines, adapted from Scopes JW, et al: Minimal rates of oxygen consumption in sick and premature infants, Arch Dis Child 41: 407, 1966

Suggested Values for Balance Of Humidity And Incubator Temperature	
Incubator Temperature	**Humidity %**
38	80
37	70
36	60
35	50
34	40

Adapted from Wasner, J, 1994 Drager Heat Balance of Premature Infants.

Appendix 3: Transitioning from an Incubator to an Open Cot

Transition from a thermally regulated environment (radiant warmer/incubator) to an open cot can occur if all the following **criteria** are met:

- Birth weight regained and weight gain following a normal curve on the growth chart (average 15-30 grams per day for a healthy preterm infant).
- Parenteral fluids < 50% of total daily fluid allowance.
- Tolerating enteral feeds (intermittent or continuous).
- No apnoea and bradycardias requiring stimulation.

Procedure

- Wean incubator air temperature by 0.5ºC when incubator air temperature has been consistently 32.0ºC or less over a minimum of 24-hour period and continue to wean incubator temp by 0.5 degree until incubator temp <29ºC.
- Once the incubator temperature is 29.0ºC to remove infant from incubator, dress in hat, booties, vest, top and cardigan (pre-warmed), wrap in cuddly and cover with blankets then place in a perspex cot away from drafts.
- Check PA temp 30 minutes post transfer until WNL and then 3-4 hourly/with cares
- Add or remove blankets or clothing as required post transition to maintain temperature WNL. Important that infant remains dressed and hat left on.
- Energy demands for thermal control take precedence over demands for growth, potentially leading to poor weight gain.
- Infants nursed in incubators for reasons other than thermal management (such as phototherapy, observation, or isolation) can be lifted out of the incubator into an open cot without following these guidelines.
- BATHING should not occur until core temperature has been maintained after transition into an open cot for at least 48 hours and the weight is > 1500 grams with no intravascular devices. See Skin Care guideline for further information about bathing and hygiene.

Failing Transition

- If the infant's axilla temperature fails to be maintained WNL during any of the above steps, the procedure should be discontinued. Rewarm under a radiant warmer prior to returning to an incubator. Set incubator temperature to last setting tolerated before transition commenced.
- Once rewarmed, consider using the cositherm to transition out of the incubator
- Other signs of unsuccessful transition include feed intolerance, apnoea and bradycardia and weight loss after transition.

Appendix 4: Heated Mattress / Cosy Therm©

The heated mattress is an external conductive heating device used for maintaining warmth for infants requiring thermoregulatory support. It can aid transition from an incubator to open cot for those infants who are more at risk of developing hypothermia.

- **Note**: It is **not** to be used as a re-warming device for infants who are hypothermic. These infants should be returned to an incubator or placed under an overhead warmer until they have rewarmed.

Temperature selection of the heated mattress is manual and is adjusted to deliver the required set temperature to maintain normothermia. It has an inbuilt pressure relief to reduce the risk of pressure injury to the infant.

Inclusion Criteria

- Infant meets criteria for transitioning out of incubator
- Previous failure to transition out of incubator

Nursing Care of Infants on a Heated Mattress
1. Set heated mattress at 37.0ºC and place a thin cotton sheet over mattress. Ensure the Perspex cot is in a draft free area of the nursery. 2. Infant should be fully dressed (vest, top, cardigan, bonnet and booties). Jump suits may be used if the infant is likely to cool during cares and feeds. 3. Nurse the infant on the mattress then cover infant with cuddly and blanket (do not swaddle as this will inhibit the heat transfer to the baby). 4. Post- transfer take PA temperature at 30 minutes. The mattress temperature should be adjusted every 30 minutes +/- 0.5ºC in response to the infant's temperature readings. 5. Continue to record axilla temperature every 30 minutes for 2 hours. 6. If normothermia is maintained for 2 hours, then temperature is monitored as standard with routine cares/feeds.

Failure to Maintain Normothermia

The mattress temperature may be increased 0.5ºC every 30 minutes until reaching 38.5ºC, if the PA temperature remains < 36.5ºC but > 36.0ºC for four consecutive readings then the infant should be placed back in an incubator for at least 24 hours.

Infants must be returned to the incubator at any time the PA temperature is < 36.0ºC or if their clinical condition deteriorates.

Weaning from the Heated Mattress

- Reducing the mattress temperature setting should commence when infant's PA temperature is stable and has remained within normal limits for 3-4 hours.

- Reduce the mattress temperature by 0.5ºC 3-4 hourly with feeds/cares as tolerated until the mattress setting is 35.0ºC.
- Once the infant is maintaining PA temperature at > 37.0ºC for 3-4 hours the heated mattress can be removed from the cot and replaced with standard thin mattress.