Space Description

The Neonatal Intensive Care Unit is located on the third floor of the new addition. Instead of looking at this area as a whole, it was broken down into two separate function areas. These two areas are the bed area, where the infants will be monitored, and the nurse’s station where the nurses will input data into the computer and perform paper work tasks when not attending to the infants.

The bed area is composed of six separate bed locations which are separated by short partitions. Each bed location can technically be considered a separate area because of the unique needs of each infant. At each bed location there usually exists a bed, a headwall composed of electrical and medical gas outlets, and some chairs for visitors to sit at. There are also wash stations and storage areas located throughout the space.

The nurses’ station area will contain about four work stations for the nurses. In this area there will be computers along with filing spaces. The nurses’ station can be treated as another space because it is relatively far away from any of the bed locations, therefore the lighting in this area will have a minimal effect on the bed areas.
Surface Properties:

<table>
<thead>
<tr>
<th>Type</th>
<th>Material</th>
<th>Reflectance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Gypsum</td>
<td>Slow Green</td>
<td>65%</td>
</tr>
<tr>
<td>Floor</td>
<td>Floor (Beige color)</td>
<td>40%</td>
</tr>
<tr>
<td>Ceiling</td>
<td>White ACT</td>
<td>85%</td>
</tr>
<tr>
<td>Glazing on Interior</td>
<td>Monolithic Clear Float Glass</td>
<td>8%</td>
</tr>
<tr>
<td>Doors</td>
<td>Wood</td>
<td>45%</td>
</tr>
<tr>
<td>Open Space</td>
<td>Open Transition in Next Space</td>
<td>30%</td>
</tr>
</tbody>
</table>

Design Concept

The appropriate lighting in the NICU requires an understanding of the disparate needs of babies and their caregivers. Even these requirements are not easily summarized, as the needs of babies vary on the basis of gestational age, medical status, and time of day, and those of their caregivers vary as well. It has been shown that by providing a lighting design specific to infant intensive care, that weight gain, length of stay, and motor skills can be improved by the time of discharge.

As described above the NICU was broken up into the bedding area and the nurses’ station. The bedding area of the NICU can be further broken up into separate lighting areas. These areas are the bed, bedside, circulation area and wash sink lighting. First let’s look at the bed lighting. We know that babies sleep for most of the day until well into the first year of life, so one goal for ambient lighting in the patient care area is to allow for sleep to occur whenever possible. Because infants have thin eyelids that allow light to pass more easily than mature eyelids and their eyes are more sensitive to light, direct lighting should not be used over the bed or in any area which could be seen by the infant. Indirect lighting, where the light source is reflected off a wall or ceiling surface before it reaches the baby, should be provided at low (dim) levels during times when critical lighting is not needed. When critical lighting on the infant is needed, a source that appears to be rather low luminance shall be used over the bed. Next let’s look at the bedside lighting. At the bedside, nurses will be reading instruments as well as recording data about the infant’s health. The lighting in this area should be able to light the instrument panels as well as provide light on the counter top with a minimal amount of light spilling into the infant’s bed area. The typical NICU has progressed from a moderately lit special care area alongside the main nursery in the 1960’s, to a brightly-lit large room with many babies in the 1980’s, to smaller, more dimly-lit pods as the new millennium arrived. The move to brightly-lit large rooms was largely driven by a need to keep a large number of critically-ill infants under constant observation, and by an assumption that such an environment was well-tolerated by infants. As it became clear that this environment had potential hazards to the developing premature infant, and monitoring techniques improved to the point that constant observation was no longer necessary for most babies, the move back to smaller, quieter, more dimly-lit pods began. In order to keep these pods at a dim light level, the circulatory lighting
should be designed to keep spill light into these pods at a minimum. Lastly, the wash sink area
should be designed so that the infants are not in discomfort from the lighting in this area while in
the basinet position. This discomfort can be avoided by providing luminaires where the infant
cannot see the light source.

Because the nurses’ station can essentially be considered a separate space, the lighting
design should consider mainly office tasks. Therefore, special considerations for VDT screens
as well as task lighting for paper tasks should be considered.

Design Criteria

Tasks:
Viewing of infants from family members, doctors and nurses
Diagnosing infant’s general condition
Reading infant’s medical charts
Viewing of VDTs
Infant lying in bassinet position
Cleaning material at sink locations
Changing infant’s clothes

Illuminance Levels:

- Horizontal Illuminance Level on Bed Tops (3’ off floor)
  Recommended value form IESNA 9th edition is Category E
  \textbf{Category E = 50 fc}
  No adjustments necessary

- Horizontal Illuminance Level on Nurses Counter (3’ off floor)
  Recommended value from IESNA 9th edition is Category D
  \textbf{Category D = 30 fc}
  No adjustments necessary

- Vertical Illuminance Level on Walls
  Recommended value from IESNA 9th edition is Category B
  \textbf{Category E = 5 fc}
  No adjustments necessary
Design Considerations:

- Lighting on both horizontal and vertical work planes should not be kept at high levels too long because infants do not have the ability to employ adult protective mechanisms to avoid retinal exposure.
- Provide a CRI > 80 so that nurses in this area can detect actual skin coloration of infants.
- Use a multi level lighting system so that the amount of light reaching the infants is lower than surrounding during the nighttime to protect the infant’s eyes.
- Any surface seen from an infant at a bassinet position should have a relatively low luminance to protect the infant’s eyes.
- Avoid highly reflective surfaces in this area to eliminate reflected glare toward infants.
- The bed, cabinet tables and peripheral should be considers as three different levels of lighting.
- Recommended reflectances for surfaces from IESNA 9th addition
  
  Ceiling = 80% to 90%
  Walls = 40% to 60%
  Furniture and Equipment = 25% to 45%
  Floors = 20% – 40%

- Luminances from task to adjacent surroundings should be no less than 33% of that on task.
- Remote darker surfaces should be no less than 25% of that on task.
- Remote lighter surfaces should be no more than 20% of that on task.
- Daylight integration is important in this type of area but does not apply to this situation.
- Use a fair amount of indirect lighting to create a relative diffuse lighting system.
- Provide a flicker-free environment by using electronic ballast for fluorescent lighting.

Control System: Use dimming system in all areas over and near infant beds to obtain the different lighting levels discussed above.
Equipment

Luminaire NG – General/Overbed Luminaires

<table>
<thead>
<tr>
<th>Luminaire</th>
<th>Maint. Category</th>
<th>Cleanliness</th>
<th>Cleaning Cycle</th>
<th>RCR</th>
<th>CIE Category</th>
<th>LDD</th>
<th>RSDD</th>
<th>LLD</th>
<th>BF</th>
<th>Total LLF</th>
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</thead>
<tbody>
<tr>
<td>NA</td>
<td>V</td>
<td>Very Clean</td>
<td>12 Month</td>
<td>2.25</td>
<td>Direct</td>
<td>0.94</td>
<td>0.98</td>
<td>0.92</td>
<td>0.9</td>
<td>0.76</td>
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</table>

Luminaire ND – Wash Sink/Desk Downlights

<table>
<thead>
<tr>
<th>Luminaire</th>
<th>Maint. Category</th>
<th>Cleanliness</th>
<th>Cleaning Cycle</th>
<th>RCR</th>
<th>CIE Category</th>
<th>LDD</th>
<th>RSDD</th>
<th>LLD</th>
<th>BF</th>
<th>Total LLF</th>
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</thead>
<tbody>
<tr>
<td>ND</td>
<td>IV</td>
<td>Very Clean</td>
<td>12 Month</td>
<td>1.4</td>
<td>Direct</td>
<td>0.94</td>
<td>0.98</td>
<td>0.86</td>
<td>1</td>
<td>0.79</td>
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Luminaire NS – Bedside Luminaires

Wall/Slot®-II
85N
Recessed Perimeter

<table>
<thead>
<tr>
<th>Luminaire</th>
<th>Maint. Category</th>
<th>Cleanliness</th>
<th>Cleaning Cycle</th>
<th>RCR</th>
<th>CIE Category</th>
<th>LDD</th>
<th>RSDD</th>
<th>LLD</th>
<th>BF</th>
<th>Total LLF</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>IV</td>
<td>Very Clean</td>
<td>12 Month</td>
<td>1.4</td>
<td>Direct</td>
<td>0.94</td>
<td>0.98</td>
<td>0.95</td>
<td>0.88</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Luminaire NB – Bed Luminaires

mark architectural lighting

<table>
<thead>
<tr>
<th>Luminaire</th>
<th>Maint. Category</th>
<th>Cleanliness</th>
<th>Cleaning Cycle</th>
<th>RCR</th>
<th>CIE Category</th>
<th>LDD</th>
<th>RSDD</th>
<th>LLD</th>
<th>BF</th>
<th>Total LLF</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>V</td>
<td>Very Clean</td>
<td>12 Month</td>
<td>1.4</td>
<td>Semi/Ind.</td>
<td>0.93</td>
<td>0.95</td>
<td>0.95</td>
<td>0.88</td>
<td>0.74</td>
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Power Density Calculation

Nurses Station Area

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Quantity</th>
<th>W/Fixture</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG</td>
<td>4</td>
<td>64</td>
<td>256</td>
</tr>
<tr>
<td>ND</td>
<td>3</td>
<td>38</td>
<td>114</td>
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<tr>
<td><strong>Total</strong></td>
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<td></td>
<td><strong>370</strong></td>
</tr>
</tbody>
</table>

Power Density = \( \frac{370W}{430 \text{ sq. ft.}} \)

\[ = 0.86 \text{ W/ft}^2 \]

Bed Area

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Quantity</th>
<th>W/Fixture</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG</td>
<td>10</td>
<td>64</td>
<td>640</td>
</tr>
<tr>
<td>ND</td>
<td>2</td>
<td>38</td>
<td>76</td>
</tr>
<tr>
<td>NS</td>
<td>6</td>
<td>64</td>
<td>384</td>
</tr>
<tr>
<td>NB</td>
<td>6</td>
<td>33</td>
<td>198</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>1298</strong></td>
</tr>
</tbody>
</table>

Power Density = \( \frac{1298W}{1220 \text{ sq ft}} \)

\[ = 1.07 \text{ W/ft}^2 \]

Power Densities **DO** comply with ASHRAE Standard 90.1 that says by using the Space-by-Space method to find your Allowable Power Density in first a Hospital Nurses’ Station Area you can not exceed a power density of 1.0 W/ft^2, and 1.5 W/ft^2 in an Exam/Treatment area such as a Neonatal Intensive Care Unit.

**Control System**

The control system for the NICU is an important tool that will allow each area within the space to be used for multiple functions. Each bed area is designed so that the lighting system in its area can be switched separately from the rest of the space as if it were a separate room. The general circulatory lighting is controlled from a secure location in the nurses’ station. The wash sink and desk downlights are switched and dimmable at a close convenient area.
**LIGHTING REDESING CONTROL SCHEDULE**

<table>
<thead>
<tr>
<th>FIXTURE TYPE</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG</td>
<td>GENERAL -ON-OFF CONTROLLED VIA SWITCH IN NURSES STATION</td>
</tr>
<tr>
<td>NG</td>
<td>OVERBED - ON-OFF CONTROLLED VIA SWITCH IN HEADWALL UNIT</td>
</tr>
<tr>
<td>ND</td>
<td>WASH SINK - CONTROLLED VIA DIMMER SWITCH AT SINK LOCATION</td>
</tr>
<tr>
<td>ND</td>
<td>DESK - CONTROLLED VIA DIMMER SWITCH IN NURSES STATION</td>
</tr>
<tr>
<td>NS</td>
<td>CONTROLLED VIA DIMMER SWITCH IN HEADWALL UNIT</td>
</tr>
<tr>
<td>NB</td>
<td>CONTROLLED VIA DIMMER SWITCH IN HEADWALL UNIT</td>
</tr>
</tbody>
</table>

**NICU Design Analysis**

**Nurses Station**

Calculations were run in AGI 32 to determine if the specified illuminance values from the design criteria were met. Below are calculation grids taken from AGI 32 in the nurses’ station to display the performance of the redesigned lighting system.

**Bedding Area**

Because of the multiple lighting scenarios, several lighting runs were calculated to determine if all scenarios will meet the prescribed design criteria. All lighting scenarios were run with the Nurses’ Station lighting on and the bedding area circulatory lighting on.

**Scenario 1**

Scenario 1 has all general circulatory lighting on as well as the lighting on in one bed area with the exception of its surgical lighting. This scenario will most likely be encountered when the nurse is checking up on an infant during the evening hours when other infants should not be disturbed.

**Scenario 2**

This scenario will investigate the performance of the lighting system when all luminaires (including all luminaires in each bed area) except for the surgical lighting area on. This will show how the lighting scenario will perform during the day when infants should be exposed to an increase in light.

**Scenario 3**

The last scenario will be calculated to evaluate the lighting system when the surgical luminaires are in use overtop of the infant as well as the general lighting for the specific bed area.
Calculation Results
All Calculations were performed in AGI 32

Nurses Station

Floor

Nurses Station Floor
Illuminance Values (Fc)
Average = 26.23 Maximum = 38.2 Minimum = 8.3
Avg/Min = 3.16 Max/Min = 4.60

Nurses Station Floor-1
Illuminance Values (Fc)
Average = 35.33 Maximum = 42.2 Minimum = 21.1
Avg/Min = 1.66 Max/Min = 1.98

Nurses Desktop

Nurses Desktop
Illuminance Values (Fc)
Average = 49.74 Maximum = 62 Minimum = 36
Avg/Min = 1.38 Max/Min = 1.72
Non-Detailed Renderings

Circulation Area

CalcPts
Illuminance Values (Fc)
Average=28.66  Maximum=38.0  Minimum=11.8
Avg/Min=2.43  Max/Min=3.22
Scenario 1:

Typical Bed
Bedside Area

**Headwall**
Illuminance Values (Fc)
Average = 47.56 Maximum = 53 Minimum = 38 Avg/Min = 1.25 Max/Min = 1.39

**bedside**
Illuminance Values (Fc)
Average = 27.57 Maximum = 41 Minimum = 16 Avg/Min = 1.72 Max/Min = 2.56

Bed Area Rendering
Bed Area Pseudo-Rendering
Scenario 2:

Typical Bed

**Bed 2**
Illuminance Values (Fc)
Average = 6.71, Maximum = 9
Minimum = 5, Avg/Min = 1.34
Max/Min = 1.80

Bedside Area

**Headwall**
Illuminance Values (Fc)
Average = 2.31, Maximum = 3
Minimum = 2, Avg/Min = 1.16
Max/Min = 1.50

**bedside**
Illuminance Values (Fc)
Average = 4.94, Maximum = 8
Minimum = 3, Avg/Min = 1.65
Max/Min = 2.67
Scenario 3:

 Typical Bed
Design Results:

Nurses’ Station
The nurses’ station lighting design came out rather well with an average of 50 fc on the desk top and a floor illuminance ranging from around 30-35 fc. There is a slight drop off in the illuminance values out in front of the desk, but will not prove to be problematic because this area leads to the NICU isolation bed. This isolation bed is separated by glass from the nurse’s station and therefore there should be a lower light level than the surroundings.

Bed Area
The lighting system design for the bedding area proved to be a good versatile lighting design. From AGI 32 I found that each bed area’s lighting system could be turned on and off without producing unwanted effects on the surrounding bed areas. The general circulation lighting performed well by providing around 30 fc on the floor and by not polluting the bed areas with unwanted light. The wash sink area utilized downlights that shielded the infant from viewing the source directly. By using the two downlights in this area, about 50 fc was provided on the table top. Fifty fc might be rather high for this area, but remember the system is dimmable and can be adjusted to the nurses’ desired light level without affecting the luminance of the luminaire. Next, the bed area calculations showed that the desired foot-candle values were obtained for each scenario. Scenario 1 proved that by utilizing only the two luminaires located behind the bed that about 21 fc can be achieved on top of the beds which would be a good light level for checking on the infants without creating a discomforting environment for them. The bedside area also turned out rather well with the wall slot luminaire providing about 45 fc at the counter top, which is an ample amount of light for the reading and writing tasks that will need to be performed in this area. Scenario 2 showed that by having only the circulatory lighting on a minimal amount of light, approximately 5 fc falls on the infants. This light level is optimal for the infants to sleep but still be viewable during the nighttime hours. Scenario 3 was performed with all lights on in the bedding area (including critical lighting). This scenario showed that in the case of an emergency about 70 fc can be found at the bed tops. Because the luminaire overtop the bed is an area source, there should be a minimal amount of shadowing during an emergency. All in all, the lighting system for the NICU proved to be an overall good design for all applications that it would be needed for.