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| **Design Guide** | |

# *Functional Requirements Specification for NEO & KoolAire*

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# Introduction

* 1. **Purpose**

The control board, with inputs and outputs, shall be controlling and monitoring entire ice machine operation including, but not limited to, the following:

* Monitoring and controlling a refrigeration system.
* Sequencing entire operation, such as, freezing and harvesting ice from the refrigeration system evaporator.
* Monitoring operational limits to protect the ice machine from major component failures.
* Sequencing self-cleaning system.
  1. **Scope**

The scope of this document is limited to the requirements for the low cost cuber ice machine controller.

1. **General Requirements**
   1. **Environmental**
      1. **Temperature**

Operating Temperature: 0°C to 65°C (32°F to 162°F)

Storage Temperature: -40°C to 85°C (-40°F to 185°F)

* + 1. **Humidity**

Operating Humidity: 10% to 95% RH, non-condensing

Storage Humidity: 10% to 100% RH, non-condensing

* + 1. **Vibration and Shock**

The ice machine shall function normally without damage from 5g sinusoidal acceleration, in the 10-250Hz frequency range. The controller shall be able to withstand a drop of 3 feet while contained in shipping package. Additionally, packaged control boards must pass the ISTA 3B shipping test.

The control board shall undergo HALT testing throughout the temperature and vibration requirements listed above to look for weak points in the board. Following is the table of test parameters for HALT testing.

**Table 1: HALT Test Parameters**

|  |  |
| --- | --- |
| **Operating and Destruct Limits Stress Condition** | **Chamber Set point** |
| Cold Temperature OL | -20°C (-13 °F) |
| Hot Temperature OL | 80°C (+176 °F) |
| Vibration OL | 20 Grms |
| Cold Temperature DL | -80°C (-112 °F) |
| Hot Temperature DL | Greater than 80°C |
| Vibration DL | 40 Grms |
| Low voltage OL | <90V |
| High voltage OL | >265V |
| Low voltage DL | <80V |
| High voltage DL | >275V |

* + 1. **Electrical Interferences**

IEC 61000-4-2 (Electrostatic discharge immunity), EN55014-1 (Radiated and Conducted Emissions), EN55014-2 (Immunity), EN61000-3-2, 3-3 (Harmonics and Flicker), EN50366 (Magnetic Field Emissions) and IEC 801-4 (Electrical Fast Transients) compliant.

* + 1. **Ground Plane**

The control board shall have proper ground plane to meet the standards specified in 2.1.4.

* + 1. **Operating Voltages**

The board shall operate at all voltage ranges from 90 – 265 VAC, 50/60 Hz.

* + 1. **Agency Approvals**

1. UL873 and CSA C22.2 No. 24 Temperature and Indicating & Regulating Equipment.
2. EuropeEN55014-1: 2006: EN55014-2: 1997
   * 1. **Electrical Standard Compliance**
3. EMC Service Description: North America (FCC Part 15, Subpart B: 2009)
4. Japan (VCCI: 2008); AZ/NZ.
5. RoHS compliance required.
6. **Machine Controller Requirements**
   1. **Microprocessor**

PIC24F 16/32 bit with at least 2K RAM, 512 EEPROM, 2 UART, 2 SPI, 2 I2C, with timer accuracy of +/- 1 seconds/day. Microprocessor memory shall be sized so that at least 30% memory reserved for future functional enhancements.

* 1. **Communication**

The low cost cuber ice machine controller shall have a test communication jack using 8 pin header (Vertical Molex SD43045-08 or equivalent). Software shall drive UART communications. This shall be used for testing the software during development and end of line test.

* 1. **Size**

The board shall not exceed 3.5” x 5.9” x 1.5” dimension unless otherwise negotiated with Manitowoc.

* 1. **Board Material Specs**

FR4 is the designated board material for the ice machine controller. In addition, the conformal coating to be used shall be Dow corning 3-1953 or equivalent as approved by Manitowoc. Connectors shall be completely free of conformal coating.

* 1. **Connectors**

Connectors on the board shall be designed such that only correct orientation and alignment is possible. Each connector shall be unique and only able to pair with the correct incoming connection.

* 1. **Fuse**

LFUSE, 3.15A 250V 5(.2) x20mm

1. **System Inputs**
   1. **Operating User Interface (UI) for Neo and KoolAire**

Neo models shall be using the UI and KoolAire models will be using a toggle switch. The program shall use the wire harness of the Neo UI or the toggle switch of KoolAire to detect if the ice maker is Neo or KoolAire, and subsequently change the program accordingly. The wire harnesses shall be independent of each, one or the other.

For KoolAire, a three position toggle switch will have the following:

* Ice
* Off (center)
* Clean

The Neo/KoolAire configuration is defined by the POWER\_DRV pin on the board.

Note: the detection on the Neo/KoolAire will only happen once (at power up).

* POWER\_DRV short = Neo
* POWER\_DRV open = KoolAire



Power on/off

Time Delay

Clean

Full Bin

Service

**Figure 1: Neo User Interface**

The Neo UI will use a 12-pin connector. KoolAire will use 3 positions of the same 12-pin connector (Ice/off/clean). Pull down resistors shall detect the configuration and change the logic between Neo and KoolAire. LED output to the external board is not necessary when using the rocker switch option.



Clean

Ice

Off

**Figure 2**: **KoolAire Toggle Switch**

* 1. **Test Mode Switch**

A momentary push button (SPST/NO) shall be place on the control board to run test mode.

* 1. **Damper Switch**

A magnetic reed switch that opens and recloses as the ice drops off the evaporator during harvest, and stays open when the bin is full.

* 1. **Low Level Float Switch (Harvest Float Switch)**

A float style reed switch in the sump trough used to terminate the *freeze* cycle and initiate the harvest cycle.

* 1. **High Level Float Switch (Ice Thickness Float Switch)**

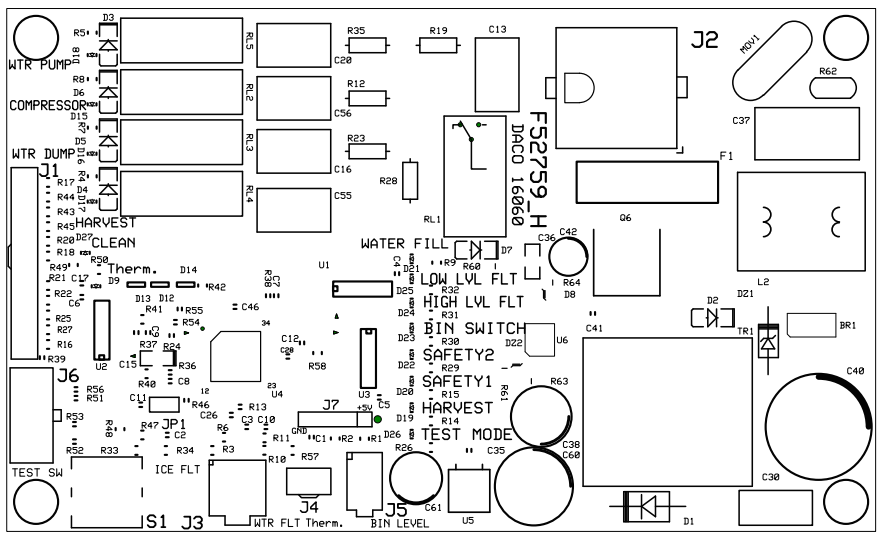
A second float style reed switch in the sump trough used to control water fill.

* 1. **Thermistor (Ice Water Temperature)**

A two wire 10k ohm thermistor used to record rate of change of ice water temperature. Operating range of thermistor in application is 20°F to 115°F resulting in expected resistance values ranging from 47,063 to 4,202 ohms.

1. **System Outputs**
   1. **Water inlet solenoid**

* 115VAC, 0.25A (1,000,000 on/off cycles)
* 230VAC, 0.13A (1,000,000 on/off cycles)
  1. **Main Compressor and Condenser Fan Contactor**
* 115VAC, 0.25A (100,000 on/off cycles)
* 230VAC, 0.13A (100,000 on/off cycles)
  1. **Water Dump Valve Solenoid**
* 115VAC, 0.25A (500,000 on/off cycles)
* 230VAC, 0.13A (500,000 on/off cycles)
  1. **Harvest Valve Solenoid**
* 115VAC, 0.25A (500,000 on/off cycles)
* 230VAC, 0.13A (500,000 on/off cycles)
  1. **Water Pump Motor**
* 115VAC, 0.25A (500,000 on/off cycles, continuous duty)
* 230VAC, 0.13A (500,000 on/off cycles, continuous duty)
  1. **Life and Misc. Requirements**
* The relays (mechanical life of 1 million cycles) driving the outputs shall be properly conditioned for transients associated with turning on-off the coils. Relays shall be properly snubbed to limit spikes of 1000V p-p.
* The silk screen on the PCB shall be marked with input & output names as defined by **Figure 3**.
* The system inputs shall be properly clamped to comply with section 2.1.4 requirements before being presented to the microprocessor.



**Figure 3: Control Board Silkscreen**

1. **System Functions**
   1. **LEDs**

Status LED indicators on user interface for NEO only:

* ON/OFF Indicator LED
* Full Bin - This indicator shall be illuminated when the damper/curtain switch is open, opposite to the damper switch LED on control board.
* Service Required
* 4 hour Delay
* 12 hour Delay
* 24 hour Delay
* Clean Indicator

Status LED (SMD 10-20 mA) indicators on the board:

* Harvest (Red)
* Safety Limit 1 (Red)
* Safety Limit 2 (Red)
* Each Relay (Red – low voltage side)
* Damper Switch (Green/Full Bin)
* Low Level Float (Green)
* High Level Float (Green)
* Test Mode (Green)
* Clean Mode (Yellow)
* Thermistor (Red)
  1. **Sequence of Operation**
     1. **Ice Making Mode**

**For Neo**

The membrane ON/OFF switch is pushed for 50ms to start the ice making mode which energizes the ON/OFF LED on the user interface. The damper switch must be closed for 2 seconds to start the ice machine operation. If the ON/OFF button is depressed again for 3 seconds, the machine shall go into shut down and the LED indicator shall turn OFF. The full bin LED on the user interface shall illuminate whenever the damper switch is open, while the full bin LED on the control board shall be OFF, the opposite for each when the damper switch is closed.

**For KoolAire**

Moving the toggle switch to ICE will start the ice making mode. The full bin LED on the control board shall be OFF on a full bin condition. When the damper/curtain switch is open the control board LED is OFF. The LED is ON when the damper/curtain switch is closed.

**Table 2: LED Conditions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Neo’s LED | | KoolAire’s LED | |
| Condition | Control Board | User interface | Control Board | User interface |
| Bin full | OFF | ON | OFF | N/A |
| NOT Bin full | ON | OFF | ON | N/A |

1. **Neo and KoolAire**, if the damper switch is open when the membrane switch is pushed to ON or toggle switch is in ICE, the control system waits until the damper switch has been closed for 2 seconds prior to entering the ice making mode.
2. For **Neo**, during the *freeze cycle*, if the damper switch is open longer than 30 seconds, the *automatic shutdown* sequence is initiated. For **KoolAire**, during the *freeze cycle*, if the damper/curtain switch is open the ice machine shall continue the *freeze cycle* until the *harvest cycle* is initiated.
3. For **Neo**, if during the *freeze cycle* the ON/OFF button is pressed and held for 3 seconds the ON/OFF LED on the user interface turns OFF with all outputs. For **KoolAire,** this occurs if the toggle switch is flipped to OFF.
   * 1. **Initial Start-up (Ice Machine State 1)**

**For Neo**

When the machine is OFF and power is applied, all lights on the membrane pad are OFF with the exception of the full bin LED. The full bin LED can be energized if the damper switch is open. At the start of the first ice making sequence, initiated by the pushing of the membrane ON/OFF button, or a change of full bin state, the dump valve solenoid is energized. The harvest solenoid is energized 1 second after the dump valve solenoid is energized. At 21 seconds, the harvest solenoid is energized, the dump valve solenoid is de-energized and the compressor contactor is energized. At 26 seconds the compressor contactor is energized and the harvest solenoid is de-energized.

The water inlet solenoid is energized after harvest solenoid turns OFF and shall remain energized until the ice thickness float has opened and remains open for 5 continuous seconds\*.

**Table 3: Neo Initial Start-up**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| At Time(sec) | Dump Valve | Water pump | Harvest | Compressor | Water Inlet |
| 0 | ON | OFF | OFF | OFF | OFF |
| 1 | ON | OFF | ON | OFF | OFF |
| 21 | OFF | OFF | ON | ON | OFF |
| 26 | OFF | OFF | OFF | ON | ON\* |

**For KoolAire**

At the start of the first ice making sequence, initiated by flipping the toggle switch to ICE or a change of full bin state, the dump valve solenoid and water pump are energized. 45 seconds into start-up, the water pump and dump valve solenoid are de-energized. The harvest solenoid is energized 50 seconds into the cycle, at 55 seconds the compressor contactor is energized and at 60 seconds the harvest solenoid is de-energized.

**Table 4: KoolAire Initial Start-up**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| At Time(sec) | Dump Valve | Water pump | Harvest | Compressor | Water Inlet |
| 0 | ON | ON | OFF | OFF |  |
| 45 | OFF | OFF |  |  |  |
| 50 |  |  | ON |  |  |
| 55 |  |  |  | ON |  |
| 60 |  |  | OFF | ON |  |
| Prechill cycle |  |  |  | ON | ON (until ice thickness float is open) |
| Total ON time: | 45 | 45 | 10 | 5 | Dependent on float |

* + 1. **Pre-chill Cycle (Ice Machine State 2)**

**For Neo**

The compressor shall run for 120 seconds on the *initial start-up* and 60 seconds for subsequent cycles. At the start of the *pre-chill cycle* the water inlet solenoid is energized to fill the trough. The water inlet solenoid will remain energized until the ice thickness float opens for 5 continuous seconds\*. Throughout the *pre-chill cycle* the water inlet solenoid may respond to the ice thickness float; meaning it will energize when the ice thickness float is closed for 1 second and de-energize when the ice thickness float is open for 5 continuous seconds.

**Table 5: Neo Pre-chill, Initial Cycle**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| At Time(sec) | Dump Valve | Water pump | Harvest | Compressor | Water Inlet |
| 26 | OFF | OFF | OFF | ON | ON\* |
| 146 | OFF | ON | OFF | ON | ON\* |

**Table 6: Neo Pre-chill, Subsequent Cycles**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| At Time(sec) | Dump Valve | Water pump | Harvest | Compressor | Water Inlet |
| 0 | OFF | OFF | OFF | ON | ON\* |
| 60 | OFF | ON | OFF | ON | ON\* |

**For KoolAire**

The compressor shall run for 120 seconds on *initial start-up* and 30 seconds on consecutive ice making cycles.

At the start of the *pre-chill* *cycle* the water inlet solenoid is energized filling the trough. The water inlet solenoid shall remain energized until the ice thickness float switch opens for 5 continuous seconds. During the entire *pre-chill cycle* the water inlet solenoid will respond to the ice thickness float, energizing when the ice thickness float has closed for 1 second and de-energizing when the ice thickness float has opened for 5 seconds.

* + 1. **Freeze Cycle (Ice Machine State 3)**

**For Neo**

Following the *pre-chill cycle* the ice maker enters the *freeze cycle* (ice machine state 3) characterized by the energizing of the water pump.

1. Following the start of the pump (start of the freeze state):
2. If the ice thickness float switch is **closed** (float is down) the water inlet solenoid shall remain energized to fill water for a maximum of 2 minutes, or until the ice thickness float switch opens for 5 continuous seconds (float is up).
3. If the ice thickness float switch is **open** (float is up) but then closes within 10 seconds of the start of the *freeze cycle*, the water inlet solenoid will re-energize and shall remain energized for up to 2 minutes or until the ice thickness float switch opens for 5 continuous seconds (float is up). This condition may exist in the transition from the *pre-chill cycle* to the *freeze cycle* when the pump is energized.
4. Pump Pause (sub-cooling prevention):
   1. Following the start of the pump the ice water temperature shall be monitored.
   2. When water temperature is equal to or less than 34 ˚F (1 ˚C) the water pump shall de-energize for a period of 25 seconds. The pump pause may occur at any point during the freeze cycle, from the start up to 45 minutes.
   3. After 25 seconds the pump shall energize. Following the start of the pump the water inlet solenoid shall energize for 7 seconds regardless of the ice thickness float state.
   4. If the water temperature does not decrease at least 5 ˚F between the start of the *freeze cycle* and 3.75 minutes into the *freeze cycle,* (e.g. thermistor is connected but not in water trough) the pump pause shall occur at 3.75 minutes into the *freeze cycle*. At 3.75 minutes the pump will de-energize for a duration of 25 seconds, after which it will energize. Following the start of the pump the water inlet solenoid shall energize for 7 seconds regardless of the ice thickness float state.
   5. Regardless of when the pump pause occurs, it shall only occur one time per ice making cycle.
   6. The thermistor shall be monitored for resistance value to detect failure of the thermistor assembly. An open failure will result in extremely high resistance, which is interpreted as extremely low temperature by the sensing circuit. A short circuit failure mode will result in very low resistance, which is interpreted as a very high temperature. If at any time during the *freeze cycle* the thermistor values fall outside of the valid temperature range of 20°F to 115°F ( -7˚C to 46˚C) the thermistor LED shall begin flashing 1 second ON, 1 second OFF on the control board and the pump pause shall default to begin at 3.75 minutes into the *freeze cycle.* At 3.75 minutes the pump will de-energize for a duration of 25 seconds, after which it will energize. Following the start of the pump the water inlet solenoid shall energize for 7 seconds regardless of the ice thickness float state. If the thermistor values are outside of the valid temperature range and then return to the valid temperature range, the following ice making cycle will use the thermistor to control the pump pause.
   7. Besides the valid temperature range diagnostics, there shall be an additional algorithm implemented between each freeze-cycle, which will check for drifts in thermistor resistance values over time. This is done by performing a thermistor value read 6 minutes into the current *freeze cycle*, then verifying that the temperature read is never above 35°F. If so, *the* ***next* *freeze cycle*** will use timed pump pause logic, which is defined as:
      * 1. At 3.75 minutes, the pump will de-energize for a duration of 25 seconds, after which it will energize. Following the start of the pump, the water inlet solenoid shall energize for 7 seconds regardless of the ice thickness float state.

A thermistor value read is performed again at the first activation of the low-water float (i.e. signifying that harvest is imminent); for comparison in the ***next* *freeze cycle***. If either the current 6-minute temp or low-water-float temp is greater than 35°F, the machine shall default to use 25-second timed pump pause and 7-second water shot on the following cycle. No LED indications are required, unless the thermistor values fall outside of the valid temperature range of 20°F to 115°F ( -7˚C to 46˚C).

* 1. or closed, (e.g. the thermistor has shorted) timed logic .



**Figure** 4: Thermistor State Diagnostic Flow Chart

**Table 7: Thermistor R-T Curve**

| R25°C=10KΩ |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Temperature (°C)** | **Temperature (°F)** | **Resistance (Ω)** |  | **Temperature (°C)** | **Temperature (°F)** | **Resistance (Ω)** |
| -7.0 | 19.4 | 47,063 |  | 19.5 | 67.1 | 12,778 |
| -6.5 | 20.3 | 45,825 |  | 20.0 | 68.0 | 12,493 |
| -6.0 | 21.2 | 44,623 |  | 20.5 | 68.9 | 12,214 |
| -5.5 | 22.1 | 43,457 |  | 21.0 | 69.8 | 11,942 |
| -5.0 | 23.0 | 42,324 |  | 21.5 | 70.7 | 11,678 |
| -4.5 | 23.9 | 41,225 |  | 22.0 | 71.6 | 11,420 |
| -4.0 | 24.8 | 40,157 |  | 22.5 | 72.5 | 11,168 |
| -3.5 | 25.7 | 39,121 |  | 23.0 | 73.4 | 10,922 |
| -3.0 | 26.6 | 38,114 |  | 23.5 | 74.3 | 10,683 |
| -2.5 | 27.5 | 37,136 |  | 24.0 | 75.2 | 10,450 |
| -2.0 | 28.4 | 36,186 |  | 24.5 | 76.1 | 10,222 |
| -1.5 | 29.3 | 35,264 |  | 25.0 | 77.0 | 10,000 |
| -1.0 | 30.2 | 34,367 |  | 25.5 | 77.9 | 9,783 |
| -0.5 | 31.1 | 33,497 |  | 26.0 | 78.8 | 9,572 |
| 0.0 | 32.0 | 32,651 |  | 26.5 | 79.7 | 9,366 |
| 0.5 | 32.9 | 31,829 |  | 27.0 | 80.6 | 9,165 |
| 1.0 | 33.8 | 31,030 |  | 27.5 | 81.5 | 8,969 |
|  | 34.0 | 30,857 |  | 28.0 | 82.4 | 8,777 |
| 1.5 | 34.7 | 30,254 |  | 28.5 | 83.3 | 8,591 |
| 2.0 | 35.6 | 29,499 |  | 29.0 | 84.2 | 8,408 |
| 2.5 | 36.5 | 28,766 |  | 29.5 | 85.1 | 8,230 |
| 3.0 | 37.4 | 28,053 |  | 30.0 | 86.0 | 8,057 |
| 3.5 | 38.3 | 27,360 |  | 30.5 | 86.9 | 7,887 |
| 4.0 | 39.2 | 26,686 |  | 31.0 | 87.8 | 7,722 |
| 4.5 | 40.1 | 26,031 |  | 31.5 | 88.7 | 7,560 |
| 5.0 | 41.0 | 25,393 |  | 32.0 | 89.6 | 7,403 |
| 5.5 | 41.9 | 24,774 |  | 32.5 | 90.5 | 7,249 |
| 6.0 | 42.8 | 24,171 |  | 33.0 | 91.4 | 7,098 |
| 6.5 | 43.7 | 23,584 |  | 33.5 | 92.3 | 6,951 |
| 7.0 | 44.6 | 23,014 |  | 34.0 | 93.2 | 6,808 |
| 7.5 | 45.5 | 22,459 |  | 34.5 | 94.1 | 6,668 |
| 8.0 | 46.4 | 21,919 |  | 35.0 | 95.0 | 6,531 |
| 8.5 | 47.3 | 21,394 |  | 35.5 | 95.9 | 6,398 |
| 9.0 | 48.2 | 20,883 |  | 36.0 | 96.8 | 6,268 |
| 9.5 | 49.1 | 20,385 |  | 36.5 | 97.7 | 6,140 |
| 10.0 | 50.0 | 19,901 |  | 37.0 | 98.6 | 6,016 |
| 10.5 | 50.9 | 19,430 |  | 37.5 | 99.5 | 5,894 |
| 11.0 | 51.8 | 18,972 |  | 38.0 | 100.4 | 5,775 |
| 11.5 | 52.7 | 18,525 |  | 38.5 | 101.3 | 5,659 |
| 12.0 | 53.6 | 18,090 |  | 39.0 | 102.2 | 5,546 |
| 12.5 | 54.5 | 17,667 |  | 39.5 | 103.1 | 5,435 |
| 13.0 | 55.4 | 17,255 |  | 40.0 | 104.0 | 5,327 |
| 13.5 | 56.3 | 16,854 |  | 40.5 | 104.9 | 5,221 |
| 14.0 | 57.2 | 16,463 |  | 41.0 | 105.8 | 5,117 |
| 14.5 | 58.1 | 16,083 |  | 41.5 | 106.7 | 5,016 |
| 15.0 | 59.0 | 15,712 |  | 42.0 | 107.6 | 4,917 |
| 15.5 | 59.9 | 15,351 |  | 42.5 | 108.5 | 4,821 |
| 16.0 | 60.8 | 15,000 |  | 43.0 | 109.4 | 4,726 |
| 16.5 | 61.7 | 14,657 |  | 43.5 | 110.3 | 4,634 |
| 17.0 | 62.6 | 14,323 |  | 44.0 | 111.2 | 4,544 |
| 17.5 | 63.5 | 13,998 |  | 44.5 | 112.1 | 4,455 |
| 18.0 | 64.4 | 13,681 |  | 45.0 | 113.0 | 4,369 |
| 18.5 | 65.3 | 13,373 |  | 45.5 | 113.9 | 4,284 |
| 19.0 | 66.2 | 13,072 |  | 46.0 | 114.8 | 4,202 |

1. Freeze lock-in time:
2. The minimum duration of a *freeze cycle* is 6 minutes. If the harvest float switch closes during the first 6 minutes, the ice machine shall remain in the *freeze cycle* until the harvest float switch has been closed for a continuous 10 seconds after the 6 minute duration.
3. The transition from *freeze* *cycle* to *harvest cycle* occurs when the harvest float switch closes for a continuous 10 seconds. This can occur at any point in the start-up cycle and any time after 6 minutes in subsequent cycles.
4. In the first cycle following an *initial start-up* the 6 minute freeze lock-in is bypassed. If the harvest float closes for 10 continuous seconds during start-up cycle a *harvest cycle* beings. Note safety limit 3 will not register on the first cycle.
5. The maximum allowable duration of a *freeze cycle* is **45 minutes**. After 45 minutes the ice maker will terminate the *freeze cycle* and enter a *harvest cycle*. If six consecutive 45 minutes freeze cycles occur the ice machine will shut down on *safety limit 1*. Refer to section 6.5 for more details.

**For KoolAire**

Following the *pre-chill cycle* the ice maker enters the *freeze cycle* (ice machine state 3) characterized by the energizing of the water pump.

1. Following the start of the pump:
2. If the ice thickness float switch is **closed** (float is down) the water inlet solenoid shall remain energized to fill water for a maximum of 6 minutes, or until the ice thickness float switch opens for 5 continuous seconds (float is up).
3. If the ice thickness float switch is **open** (float is up) but then closes within 10 seconds of the start of the *freeze cycle,* the water inlet solenoid will re-energize and shall remain energized for up to 6 minutes or until the ice thickness float switch opens for 5 continuous seconds (float is up). This condition may exist in the transition from the *pre-chill cycle* to the *freeze cycle* when the pump is energized.
4. There is no pump pause on KoolAire and thus the thermistor circuit on KoolAire is unused. The thermistor LED should remain OFF at all times on KoolAire models.
5. If at 3 minutes from the start of the *freeze cycle* the ice thickness float switch is open (float is up) and the water inlet solenoid has de-energize, the water inlet solenoid shall energize for 12 seconds. If at 3 minutes from the start of the *freeze cycle* the ice thickness float switch has not opened, the water inlet solenoid shall remain energized until the ice thickness float switch closes or until the time reaches a maximum of 6 minutes.
6. Freeze lock-in time:
7. The minimum duration of a *freeze cycle* is 6 minutes. If the harvest float switch closes during the first 6 minutes, the ice machine shall remain in the *freeze cycle* until the harvest float switch has been closed for a continuous 10 seconds after the 6 minute duration.
8. The transition from *freeze* *cycle* to *harvest cycle* occurs when the harvest float switch closes for a continuous 10 seconds.
9. In the first cycle following an *initial start-up* the 6 minute freeze lock-in is bypassed. If the harvest float closes for 10 continuous seconds a *harvest cycle* beings. Note safety limit 3 will not register on the first cycle.

1. The maximum allowable duration of a *freeze cycle* is **60 minutes**. After 60 minutes the ice maker will terminate the *freeze cycle* and enter a *harvest cycle*. If six consecutive 60 minutes freeze cycles occur the ice machine will shut down on *safety limit 1*. Refer to section 6.5 for more details.
   * 1. **Harvest Cycle (Ice Machine State 4):**

**For Neo**

The harvest solenoid is energized and the harvest indicator LED on the control board is illuminated. At 1 second the water pump is de-energized and at 2 seconds the dump valve solenoid is energized. The dump valve solenoid shall remain energized until 22 seconds, after which it is de-energized. The compressor contactor remains energized during the harvest cycle. When the ice is harvested, the ice falling off the evaporator opens the damper switch.

1. If the damper switch opens, and then closes within 30 seconds of opening, a *pre-chill* *cycle* begins.
2. If the damper switch opens and remains open for more than 30 seconds, the ice maker enters an *automatic* *shutdown* (all components are de-energized) and the full bin LED on the Neo user interface is energized.
3. If damper switch is open when the ice machine enters a *harvest cycle* and the harvest time reaches 3.5 minutes without the damper switch closing to detect a harvest, the ice machine enters an *automatic* *shutdown*.
4. If the damper switch does not open and then close within 30 seconds of opening and the harvest time reaches 3.5 minutes, the ice maker shall use a water assisted harvest for an additional 3.5 minutes. At 3.5 minutes the compressor contactor coil and harvest solenoid remain energized. The water inlet solenoid will energize filling the trough for a maximum of 105 seconds or until the ice thickness float switch opens for 5 continuous seconds. At 4 minutes the water pump energizes. At 6.5 minutes the dump valve solenoid energizes and the water pump de-energizes. Water assisted harvest will terminate at 7 minutes while checking for the damper to open and subsequently close within 30 seconds.
   1. If the damper opens and then closes within 30 seconds, the ice machine will enter a *pre-chill cycle* (state 2).
   2. If damper opens and remains open during the 7.0 minute water assisted harvest, the ice machine enters an *automatic shutdown* (all components are de-energized) and energizes the full bin LED on the Neo user interface.
   3. If the damper does not open and then close during the 7.0 minute water assisted harvest, the ice machine shall go to a *water thaw cycle* (ice machine state 10).
   4. If three consecutive 7.0 minute harvest cycles occur the ice machine will shut down on safety limit 2. Refer to section 6.5 for more details.

**Table 8: Neo Harvest Cycle**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| At Time(sec) | Dump Valve | Water pump | Harvest | Compressor | Water Inlet |
| 0 | OFF | ON | ON | ON | OFF |
| 1 | OFF | OFF | ON | ON | OFF |
| 2 | ON | OFF | ON | ON | OFF |
| 22 | OFF | OFF | ON | ON | OFF |
| 210 | OFF | OFF | ON | ON | ON, (until ice thickness float is open, or max. time 105 seconds) |
| 240 | OFF | ON | ON | ON |
| 390 | ON | OFF | ON | ON |
| 420 | OFF | OFF | OFF | OFF |

**Table 9: Curtain Switch Response during Harvest Cycle**

|  |  |  |
| --- | --- | --- |
| **Time in Harvest (State 4)** | **Curtain switch position during harvest, state 4**  **1 = damper closed**  **0 = damper open** | **Response** |
| 0-420 sec. | A. 1 to 0 to 1, ≤ 30 sec. duration | Go to prechill, state 2 |
| B. 1 to 0 > 30 sec. duration | Go to auto shut down, state 5 |
| C. 0 (switch open start of harvest) > 30 sec duration | Go to auto shut down, state 5 |
| D. 0 (switch open start of harvest) to 1, ≤ 30 sec. duration | Go to prechill, state 2 |
| > 420 sec. | 1 (switch never opened) | Go to water thaw, state 10 |

**For KoolAire**

The harvest solenoid and dump valve solenoid are energized. The water pump and dump valve solenoid remain energized for 45 seconds. The compressor contactor remains energized during the *harvest cycle*. When the ice is harvested, the ice falling off the evaporator opens the damper/curtain switch.

1. If the damper/curtain switch opens and then closes within 3.5 minutes the ice maker begins a *pre-chill* *cycle*. If the damper/curtain switch is open after 3.5 minutes the ice machine will enter an *automatic shutdown* (all components are de-energized) and the bin level LED on the control board will remain OFF.
2. During the *harvest cycle*, if the damper/curtain switch is opened and remains open for more than 30 seconds, the ice machine enters an *automatic shutdown* (all components are de-energized) and the bin level LED on the control board will remain OFF.
3. If the water curtain is removed during the *freeze cycle* (for service tech to view the ice formation) and the *harvest cycle* is initiated, the ice machine will execute a 3.5 minute *harvest cycle* followed by:
   1. A *pre-chill cycle;* if the curtain is replaced during the 3.5 minute harvest for 2 seconds.
   2. An *automatic shutdown;* if the curtain is not detected during the 3.5 minute *harvest cycle*, all components shutdown and the bin level LED on the control board will energize.
   3. If 100 consecutive 3.5 minute harvest cycles occur the ice machine will shut down on safety limit 2. Refer to section 6.5 for more details.
      1. **Water Thaw Cycle (Ice Machine State 10)**

**For Neo**

The harvest LED indicator on the board remains energized. The dump valve solenoid, harvest solenoid and contactor coil will de-energize. The water inlet solenoid shall energize and at 30 seconds the water pump energizes. The water inlet solenoid remains energized for a maximum of 105 seconds or until the ice thickness float switch (high float) opens for 5 continuous seconds following the start of the pump. The water pump shall remain energized until 2.5 minutes.

1. If the damper opens, and then closes within 30 seconds, the ice machine shall continue the *water thaw cycle* (state 10).
2. At 170 seconds the dump valve solenoid is de-energized and a new *water thaw cycle* is started. 1 cycle is added to the counter for the *water thaw cycle*.
3. After 2 completed *water thaw cycles* the ice maker shall enter an *initial start-up* (state 1) and the harvest LED indicator on the control board shall be de-energized.
4. If there is a power interruption during *water thaw cycle,* the ice maker will re-start in the *harvest cycle.* (see section 0)

**Table 10: Neo Water Thaw Cycle (State10)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Time at start of state 10 (sec) | Dump Valve | Water pump | Harvest | Compressor | Water Inlet |
| 0 | OFF | OFF | OFF | OFF | ON, (until ice thickness float opens or max. time 105 seconds) |
| 30 | OFF | ON | OFF | OFF |
| 150 | ON | OFF | OFF | OFF | OFF |
| 170 | Dump valve turns off.  Add 1 count for thaw cycle.  If count < 2 then repeat thaw cycle, time 0-170 sec.  If count =2 then go to initial startup, state 1 | | | | |

**Table 11: Curtain Switch Response during Neo Water Thaw Cycle**

|  |  |  |
| --- | --- | --- |
| **Time in water thaw cycle (State 10)** | **Curtain switch position during water thaw cycle, state 10**  **1 = damper closed**  **0 = damper open** | **Response** |
| 0-170 sec. | A. 1 to 0 to 1, ≤ 30 sec. duration | Stay in water thaw, state 10 |
| B. 0 (switch open start of water thaw) to 1, ≤ 30 sec. duration | Stay in water thaw, state 10 |
| C. 1 (switch never opened) | Stay in water thaw, state 10 |

* + 1. **Automatic Shutdown Sequence (Ice Machine State 5)**

**For Neo**

*Automatic* *shutdown* of all electrical components occurs after the damper/curtain switch is open for more than 30 seconds following a *harvest cycle*. The ice machine shall remain OFF for a minimumof 3 minutes and the damper/curtain switch must be closed for 2 continuous seconds (debounce) before entering an *initial start-up*. During automatic shutdown if the ON/OFF button is pressed:

1. Frist Time: The ice machine shall turn OFF and de-energize the ON/OFF LED on the Neo user interface.
2. Second Time: The ice machine shall turn ON after the damper closes, the ON/OFF LED on the Neo user interface shall energize.
3. The sequence (1) shall be repeated with an odd number of ON/OFF button presses and sequence (2) shall be repeated with an even number of ON/OFF button presses.

**For KoolAire**

*Automatic* *shutdown* of all electrical components is based on the conditions during the *harvest cycle*. The ice machine shall remain OFF for a minimumof 3 minutes and the damper/curtain switch must be closed for 2 continuous seconds (debounce) before entering an *initial start-up*. During automatic shutdown, if the toggle switch is:

1. Flipped from ICE –OFF –ICE, the 3 minute delay is bypassed. If the damper/curtain is closed the ice machine enters *initial start-up* and if the damper/ curtain is open, the ice machine will wait until it closes before starting.

* + 1. **Power Interruption Sequence (Ice Machine State 0)**

**For Neo**

After a power interruption, on recovery the ice machine shall enter a *harvest cycle* (7 minutes maximum or until the damper opens and then closes) followed by:

1. If before the power interruption the ice machine was in state 1 (initial start-up), 2 (pre-chill), 3 (freeze) or 4 (harvest), the ice machine will enter a ***pre-chill cycle.***
2. If before the power interruption the ice machine was in 7 (delay 4 hours), 8 (delay 12 hours), or 9 (delay 24 hours), the ice machine will remain **OFF.**
3. If before the power interruption the ice machine was in state 0 (OFF), 5 (automatic shutdown), 6 (cleaning sequence), or “test mode”, the ice machine will remain in the state it was in previous to the power interruption.

**For KoolAire**

After a power interruption, the state of the ice machine will depend on the position of the toggle switch (ICE-OFF-CLEAN):

1. OFF; the ice machine will remain OFF until the machine is started.
2. ICE; if the curtain switch is open the ice machine will remain in state 5 (automatic shutdown). If the curtain switch is closed the ice machine will start a *harvest cycle* which will be followed with a *pre-chill cycle*.
3. CLEAN; the ice machine will restart in state 6 (cleaning sequence).
   1. **Cleaning Sequence (Ice Machine State 6)**
      1. **Neo**

With the ice machine OFF, pressing and holding the clean button on the Neo UI for 3 continuous seconds will start a *cleaning sequence*. The *cleaning sequence* cannot be entered when the damper switch is open. If the damper switch is opened for more than 2 seconds during the *cleaning sequence*, the *clean sequence* is paused. If the damper switch stays open for more than 30 seconds, the ice machine enters an *automatic shutdown*. During the *cleaning sequence*, the clean indicator LED on the board, the clean LED on the UI and the ON/OFF LED on the UI shall be energized and remain energized until the *cleaning sequence* is complete.

1. The *cleaning sequence* is aborted if the clean button is pressed within 45 seconds of its initiation, the clean LED on control board and UI will de-energize.
2. If the ON/OFF button is pressed at any time during the cleaning sequence, the ON/OFF LED shall be de-energized to indicate that the unit shall remain OFF upon completion of the *cleaning sequence*.
3. If the clean button is pressed at any time after 45 seconds of the *cleaning sequence* initiation, the *cleaning sequence* shall be paused, the ON/OFF LED and clean LED on UI and control board shall flash one second ON, one second OFF until the clean button is pressed again to resume the cleaning sequence. During condition (2), the ON/OFF LED shall remain OFF.
4. Pressing the test button on the control board at any time during the *cleaning sequence* exits the *cleaning sequence*. The ice machine shall then remain OFF and all LEDs shall be de-energized.

**Table 12: Neo Cleaning Sequence**

|  |  |  |
| --- | --- | --- |
| **Event** | **Time/Cycle** | **Components Energized** |
| **Dump** | 45 seconds | Dump valve solenoid |
| **Fill**  **Clean**  **Dump** | Until ice thickness float is open or 60 seconds maximum  600 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid (until ice thickness float is open)  Dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid (until is thickness float is open)  Dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Dump valve solenoid |

* + 1. **KoolAire**

When the toggle switch is turned to CLEAN the ice machine will initiate the *cleaning sequence*. At the end of the *cleaning sequence* the ice machine will turn OFF until the toggle switch is flipped to another state.

1. The *cleaning sequence* will operate with or without the water curtain (curtain switch open or closed).
2. If the toggle switch is turned to OFF after the *cleaning sequence* has started the ice machine will turn OFF.
3. If the toggle switch is turned to ICE within 45 seconds of the *cleaning sequence* initiation, the *cleaning sequence* is aborted.
4. After 45 seconds, the toggle switch can be switched to the ICE position and the ice machine will enter an *initial start-up cycle* following the completion of the *cleaning sequence*. Entering an *initial start-up cycle* is dependent on the status of the curtain switch; if the curtain switch is open the ice maker will remain OFF until the curtain is closed.
5. If the toggle switch is turned back to the CLEAN position, a new *cleaning sequence* is started.
6. If the toggle switch is turned to ICE after the *cleaning sequence* is started, the *cleaning sequence* can be aborted by turning the switch to OFF and back to the ICE position.
7. If there is a power interruption during the *cleaning sequence,* upon recovery the ice machine will restart the *cleaning sequence*.

**Table 13: KoolAire Cleaning Sequence**

|  |  |  |
| --- | --- | --- |
| **Event** | **Time/Cycle** | **Components Energized** |
| **Dump** | 45 seconds | Water pump and dump valve solenoid |
| **Fill**  **Clean**  **Dump** | Until ice thickness float is open or 60 seconds maximum  600 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid (until ice thickness float is open)  Water pump and dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Water pump and dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Water pump and dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Water pump and dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Water pump and dump valve solenoid |
| **Fill**  **Rinse**  **Dump** | Until ice thickness float is open or 60 seconds maximum  90 seconds  45 seconds | Water inlet solenoid  Water pump and water inlet solenoid(until ice thickness float is open)  Water pump dump valve solenoid |

* 1. **Delay Mode (Ice Machine States 7-9)**

**For Neo**

When the ice machine is powered ON, when in states 1, 2, 3, 4, 5 or 10 the *delay mode* activates when the delay button is pressed on the UI.

1. The machine shuts down for 4, 12 or 24 hours as the delay button is pressed one, two or three times respectively. The corresponding delay period LED will be illuminating as the delay button is pressed.
2. At the start of *delay mode* the UI ON/OFF LED will de-energized.
3. The *delay mode* shall begin at the completion of the *harvest cycle* which follows the *delay mode* activation during states 1 (initial start-up), 2 (pre-chill), 3 (freeze) or 4 (harvest). The ice machine shall enter an *initial start-up cycle* after the selected delay period.
4. The *delay mode* shall begin immediately when activated in ice machine states 5 (automatic shutdown) or 10 (water thaw cycle).
5. Four presses of the delay button shall cancel the *delay mode* and turn OFF the corresponding LEDs.
6. If the machine is in 4 or 12 hours *delay mode* when delay button is pressed, it moves to the next *delay mode* and the clock resets (e.g. if the machine is in 4 hours *delay mode* and the user pushes the delay button, the machine will enter 12 hours delay starting that moment)
7. When the machine is in *delay mode*, pressing the ON/OFF button shall cancel the *delay mode*, turn OFF the corresponding LEDs and resume ice making by entering an *initial start-up cycle*.
   1. **Safety Limits**

The following operational safety limits shall be programmed into the processor to protect the machine from major system component failures.

* + 1. **Safety Limit 1: Long Freeze Cycle**

**For Neo**

The maximum freeze time shall be limited to 45 minutes, after completion of a 45 minute *freeze cycle* the program shall initiate a *harvest cycle*. If the 45 minute freeze time limit is reached in 3 consecutive cycles, the safety limit 1 LED on the board shall start flashing 1 second ON and 1 second OFF. After 6 consecutive 45 minute *freeze cycles* the ice maker shall complete a *harvest cycle*, enter an *automatic* *shutdown* and energize the board safety limit 1 LED and the UI service LED. When the ice machine is turned ON following a shutdown, the UI service LED shall flash once to indicate safety limit 1 shutdown. The safety limit LED on the board shall also flash once on restart and shall continue to do so until 100 freeze/harvest cycles have been counted. After a power recycle from the UI the 6 consecutive harvest cycle counter is reset. After 100 consecutive ice making cycles (less than 45 minutes), the LED counter is reset so the safety limit LED on the board does not flash with an *initial start-up cycle.*

**For KoolAire**

The maximum freeze time shall be limited to 60 minutes, after completion of a 60 minute *freeze cycle*, the program shall initiate a *harvest cycle*. If the 60 minute freeze time limit is reached in 3 consecutive cycles, the safety limit 1 LED on the board shall start flashing 1 second ON and 1 second OFF. After 6 consecutive 60 minute *freeze cycles* the ice maker shall complete a *harvest cycle,* enter an *automatic shutdown* and energize the board safety limit 1 LED. The board safety limit 1 LED will also flash once on restart and shall continue to do so until 100 freeze/harvest cycles have been counted. After 100 consecutive ice making cycles (less than 60 minutes), the counter is reset so the safety limit does not flash on start up.

* + 1. **Safety Limit 2: Long Harvest Cycle**

**For Neo**

If the *harvest cycle* time reaches its maximum of 7 minutes, the harvest limit flag is set and the safety limit 2 LED on the control board shall start flashing 1 second ON and 1 second OFF. If the maximum harvest time limit is reached in 3 consecutive cycles, the ice maker enters an *automatic* *shutdown* after completing the *water thaw cycle*, state 10, and energizes the service LED on UI and the safety limit 2 LED on the board. When the ice machine is turned ON following a shutdown, the service LED on UI shall flash twice to let users know that the machine shutdown on safety limit 2. The safety limit 2 LED on the board shall flash twice on restart until 100 freeze/harvest cycles have been counted. After a power recycle from the UI the 3 consecutive harvest cycle counter is reset. After 100 consecutive harvest cycles (less than the maximum in State 4), the LED counter is reset so the safety limit LED on board does not flash on start up.

**For KoolAire**

If the harvest cycle time reaches 3.5 minutes, the program shall de-energize the harvest valve and initiate a *pre-chill* cycle. The harvest limit flag is set after 3 consecutive 3.5 minute harvest cycles and the safety limit 2 LED on the control board shall start flashing 1 second ON and 1 second OFF. If the maximum harvest time limit is reached in 100 consecutive cycles, the program shall initiate a safety limit *shutdown* sequence energizing the safety limit 2 LED on the board. The safety limit 2 LED on the board shall flash twice on restart until 100 freeze/harvest cycles have been counted. After 100 consecutive harvest cycles (less than 3.5 minutes), the counter is reset so the safety limit LED on board does not flash on start up.

* + 1. **Safety Limit 3: Water Loss**

In all cycles except for the *initial start-up cycle,* if the harvest float switch does not open within 4 minutes into the *freeze cycle* the program shall initiate a safety limit shutdown. The service LED on the Neo UI shall flash 1 second ON and 1 second OFF. The SL1 and SL2 LEDs on the control board shall flash 1 second ON and 1 second OFF. The ice machine shall restart with an *initial start-up cycle* 30 minutes after shutdown and turn OFF the SL1 and SL2 LEDs on board and the service LED on the Neo UI. During the automatic restart if the harvest float does not open by the end of the *pre-chill cycle* the program shall again initiate a safety limit shutdown. The automatic restart shall occur for 100 consecutive cycles at which point the machine shall remain OFF and the SL1, SL2 and service LEDs on the Neo UI will remain energized. During a shutdown, pressing the ON/OFF button once will turn the machine OFF; pressing the ON/OFF button a second time will turn the machine ON, bypassing the 30 minute delay. Pressing the ON/OFF button shall turn OFF the service LED on the Neo UI. When the ice machine is turned ON, the service LED on the Neo UI will flash 3 times. The SL1 and SL2 on the board shall flash 3 times on restart and shall continue to do so for 100 consecutive cycles.

* 1. **Test Mode**

The ice machine must be OFF, pressing and holding the test mode button for 3 seconds shall initiate the *test mode*. During *test mode*, all LEDs on the board and all relays shall energize in 1 second intervals. The relays shall energize in the following order: harvest valve solenoid, water pump, dump valve solenoid, water inlet solenoid, and compressor contactor. For **Neo**, all LEDs on the Neo UI shall energize. LEDs and relays shall remain energized for 2 minutes and then turn OFF. Following the 2 minute period the ice machine shall run 500 complete ice making cycle (from *initial start-up cycle* to *harvest cycle*) and then shutdown. The ice making sequence during *test mode* shall be the KoolAire ice making sequence.

The curtain switch can be open or closed during *test mode*. Pressing the test mode button at any time during *test mode* exits the *test mode* and turns OFF all outputs. The test mode LED will be energized for the duration of *test mode*. The *test mode* shall run even when the Neo UI is disconnected from the board. All Neo UI and KoolAire rocker switch inputs shall be disabled during *test mode*. For **KoolAire**, after *test mode* is complete the ice maker will being an *initial start-up cycle* if the toggle switch is in the ICE position, begin a *cleaning sequence* if in the CLEAN position, or remain OFF if in the OFF position.

1. **Gateway & Modbus Registers**

The Neo/KoolAire control board shall have the ability to communicate with DIGI Connect Core 3G gateway devices through the UART port. The control board shall also have the ability to communicate with a PC running Modbus application. The purpose is to monitor and collect the data from the ice machine by monitoring the inputs and timing of the control board.

**Computer**

**Ice machine control board**

**Computer**

**Remote Gateway**

**Ice machine control board**

* 1. **Registers or Data**

Table 14 is a list data registers that would be beneficial in monitoring the state of the ice machine. The control board shall be capable of providing data from 1 second to 30 minute intervals.

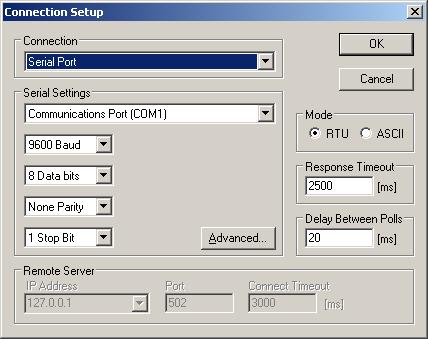
**Table 14**

| **Register Number** | **Function** | **Format** | **Description** | **Details on how the data shall be used.** |
| --- | --- | --- | --- | --- |
| 0 | Software version |  | Displays software version of the machine. |  |
| 1 | State of the ice machine | 0 = Off,  1= Purge,  2= Prechill,  3 =Freeze,  4 = Harvest,  5 = Full bin,  6 = Clean,  7 = Delay mode for 4 hrs.,  8= Delay mode for 12 hrs.,  9 = Delay mode for 24 hrs.  10= Thaw cycle | Shows machine status. The state is defined as the condition the ice machine is in at the time, see section 6. | Monitored continuously to show the status of the ice machine over a period of time. |
| 2 | Freeze time | Seconds | Last freeze time (in seconds) per ice making cycle. The freeze time is held in the register until the next complete freeze cycle. | Monitoring over a period of time to see if the freeze time is varying over a period of time i.e. indicates symptoms, of lack of lack water, refrigeration system not working properly. |
| 3 | Harvest Time | Seconds | Last harvest time (in seconds) per ice making cycle. The harvest time is held in the register until the next complete harvest cycle. | Monitoring over a period of time to see if the harvest is normal, i.e. dirty evaporator, thin ice bridge |
| 4 | Water Fill Time | Seconds | Total water fill time (in seconds) per ice making cycle. The water fill time will start and stop based on the water valve cycling on and off. The accumulated fill time is held in the register until the start of the next prechill or state 2. | When monitoring over time, tells if there is problem with over flowing, water supply issues, water valve issues |
| 5 | High float Status | 1= Float is up, switch electrical open.  0= Float is down, switch is electrically closed. | Status of high level float | Monitoring over a period of time to show the state of the float during the ice making cycle, i.e. normal operation to a sticking float. |
| 6 | Low float Status | 1= Float is up, switch electrical open.  0= Float is down, switch is electrically closed. | Status of low level float | Monitoring over a period of time to show the state of the float during the ice making cycle, i.e. normal operation to a sticking float. |
| 7 | Curtain switch Status | 1= curtain is open, switch is electrical closed.  0 = curtain is closed, switch is electrical open. | Status of the damper/curtain switch | Monitoring over a period of time to show the state of the curtain switch during the ice making cycle, i.e. bin full condition. |
| 8 | Cycles | X= total number of ice making cycles after harvest. | Total no. of ice making cycles over the life of the ice machine. | Allows an estimate the number of cycle over a period time. |
| 9 | Full bin open time | Minutes | Number of minute’s machine is in full bin mode. Resets at the beginning of pre-chill every cycle. | Allows an estimate of the usage of ice over a period of time. |
| 10 | High float cycles | X = number cycles | No. of high level float cycles per ice making cycle | Allows an estimate of the how many time the float shall cycle over a period of time for reliability |
| 11 | Low float cycles | X = number cycles | No. of low level float cycles per ice making cycle. | Allows an estimate of the how many time the float shall cycle over a period of time for reliability |
| 12 | Status Long freeze Safety limit 1 | 1= reached limit count or shut down of the ice machine, 0 = normal operation | Safety limit 1 status. | Allows seeing if the ice machine is off due to a long freeze limit. |
| 13 | Status Long Harvest  Safety Limit 2 | 1= reached limit count or shut down of the ice machine, 0 = normal operation | Safety limit 2 status. | Allows seeing if the ice machine is off due to a long harvest limit. |
| 14 | Compressor Cycles | X = number cycles | Total no. of compressor cycles over the life of the ice machine. | Allows an estimate of the how many time the compressor shall cycle over a period of time for reliability |
| 15 | Water Valve Cycle | X = number cycles | Total no. of water inlet valve cycles over the life of the ice machine. | Allows an estimate of the how many time the water valve shall cycle over a period of time for reliability |
| 16 | Harvest Valve Cycles | X = number cycles | Total no. of harvest valve cycles over the life of the ice machine. | Allows an estimate of the how many time the harvest valve shall cycle over a period of time for reliability |
| 17 | Dump Valve  Cycles | X = number cycles | Total no. of dump valve cycles over the life of the ice machine. | Allows an estimate of the how many time the dump valve shall cycle over a period of time for reliability |
| 18 | Water Pump Cycles | X = number cycles | Total no. of water pump cycles over the life of the ice machine. | Allows an estimate of the how many time the water pump shall cycle over a period of time for reliability |
| 19 | Reset IM | 0 to 1 reset the IM to purge state. 1 to 0 to shut the ice machine off. |  | Feature to reset the ice machine remotely if shut off on a safety limit 1 or 2, or shut off the ice machine for a long freeze cycle. |
| 20 | Control board ID | X=0000 |  | Allows a unique identifier of the control board to be associated with an ice machine for field or EOL testing. |
| 21 | Test Safety Limit 1 | X= number cycles | Increase the cycle count to allow shorting up the test time. (save on eeprom until condition to come out of safety limit satisfied) | Using modbus write a count to advance the counter for long freeze, i.e. write 5, wait 60 min. and the next cycle should shut off on SL1. |
| 22 | Test Safety Limit 2 | X= number cycles | Increase the cycle count to allow shorting up the test time. (save on eeprom until condition to come out of safety limit satisfied) | Using modbus write a count to advance the counter for long harvest, i.e. write 499, wait 3.5 min. and the next cycle should shut off on SL2. |
| 23 | Test Safety Limit 3 | X= number cycles | Increase the cycle count to allow shorting up the test time. (save on eeprom until condition to come out of safety limit satisfied) | Using modbus write a count to advance the counter for no water, i.e. write 99, wait 6 min. and the next cycle should shut off on SL3. |
| 24 | Status water fault safety limit 3 | 1 = reached limit; 0 = normal operation | Safety limit 3 status | Allows seeing if the ice machine is off due to a water fault safety limit. |
| 25 | Water thaw time | Seconds | Time ice maker was in water thaw cycle (state 10) | Allows engineering to see the time spent in this state |
| 26 | Thermistor Temperature | Degrees Fahrenheit | Current temperature reading of thermistor | Allows engineering team to monitor ice water temperature to ensure subcooled water does not exist. |
| 27 | Time to pump pause | Seconds | Freeze time before pump pause occurs | Allows engineering team to monitor when the pump pause occurs, ensuring it is before the water temperature reaches 34°F. |
| 94 | Manitowoc Serial #1 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 95 | Manitowoc Serial #2 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 96 | Manitowoc Serial #3 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 97 | Manitowoc Serial #4 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 98 | Manitowoc Serial #5 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 99 | Manitowoc Serial #6 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 100 | Manitowoc Serial #7 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 101 | Manitowoc Serial #8 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 102 | Manitowoc Serial #9 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 103 | Manitowoc Serial #10 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 104 | Manitowoc Serial #11 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 105 | Manitowoc Serial #12 | Numeric | Entering Manitowoc Serial number | For field and life test of entering the serial # for tracking with Digi |
| 106 | Test site | S (1-3) | DACO Control Board Serial # | Used by DACO and MII End of line testing to identify control board to ice machine. |
| 107 | Test number | T(1-6) | DACO Control Board Serial # | Used by DACO and MII End of line testing to identify control board to ice machine. |
| 108-109 | Year | YY(00-99) | DACO Control Board Serial # | Used by DACO and MII End of line testing to identify control board to ice machine. |
| 110-112 | Days of the year | DDD(1-365) | DACO Control Board Serial # | Used by DACO and MII End of line testing to identify control board to ice machine. |
| 113-116 | Sequential number | NNNN(0-9999) | DACO Control Board Serial # | Used by DACO and MII End of line testing to identify control board to ice machine. |

Example of the DACO serial number:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Test site | Tester number | year | Days of the year | Sequential  number |
| Modbus Register | 106 | 107 | 108-109 | 110-112 | 113-116 |
| Format | S (1-3) | T(1-6) | YY(00-99) | DDD(1-365) | NNNN(0-9999) |
| Example | 1 | 1 | 13 | 031 | 0001 |
| Readout | 11130310001 = Tested on test site 1, tester 1, on Jan31, 2013, first board(0001) | | | | |

1. **Appendix**
   1. **Modbus Setup**
      1. **Connection Setup**

****

**Write Serial Number (Function code: 16)**

functionbar

|  |  |
| --- | --- |
| Description: P:\Temp\To_Tyu\Manitowoc\modbus\modbus POll\writeSerial.JPG | 1. Press the “16” button. 2. Press Open and select writeSerial.mod(optional) 3. Enter the following:   Slave ID: 1  Address: 93  Quantity:12   1. If writeSerial.mod is used, the default serial Number is 123456789321 starting from 093 ended with 104. 2. Change the numbers as needed. 3. Press Send button to save. (Response OK should pop-up). |
| Example: Write Serial Number: 123456789321 |  |

**Read Serial Number (Function code: 23)**

functionbar

|  |  |
| --- | --- |
|  | Read Manitowoc Serial Number   1. Press the “23” button. 2. Enter the following:   Slave ID:1  Write Address: 1\*  Write Quantity: 21\*  Read Address: 93  Read Quantity: 12   1. Press Send (Response OK should pop-up). 2. Serial Number is displayed on the Read Result window.   \*can be any number from 1 to 255 |
| Example: Manitowoc serial number is not set  (read:69 , “E” in ASCSII ) |  |
|  | Read Results are encoded as ASCII.  From this example,   |  |  |  |  | | --- | --- | --- | --- | | Address | Readout |  | Serial # | | 093 | 49 | - 48 = | 1 | | 094 | 50 | 2 | | 095 | 51 | 3 | | 096 | 52 | 4 | | 097 | 53 | 5 | | 098 | 54 | 6 | | 099 | 55 | 7 | | 100 | 56 | 8 | | 101 | 57 | 9 | |  |  |  | |
|  |  |

|  |  |
| --- | --- |
|  | Read DACO Serial Number   1. Press the “23” button. 2. Enter the following:   Slave ID:1  Write Address: 1\*  Write Quantity: 21\*  Read Address: 106  Read Quantity: 11   1. Press Send (Response OK should pop-up). 2. Serial Number is displayed on the Read Result window. |
| Example: This board does not have serial number  (read:25,5,25,5…..) |  |
|  | \*can be any number from 1 to 255 |
| Example: This board DACO serial number(read:99936599…(11 digits)) |  |

|  |  |  |
| --- | --- | --- |
| **Summary** | **Read Manitowoc Serial Number** | **Read Daco Serial Number** |
| **Function code** | **23** | |
| **Read Address** | **93** | **106** |
| **Read Quantity** | **12** | **11** |
| **serial number is not set** | **Read 69,”E”** | **Read 25,5,25,5…** |
|  |  |  |

**Reset IM (Function code: 06 register 19)**

functionbar

|  |  |
| --- | --- |
|  | 1. Double click the value showed on the Reset IM will pop-up a write single register prompt.   Description: P:\Temp\To_Tyu\Manitowoc\modbus\modbus POll\ResetIM.JPG   1. Change the Value to   0: Machine shutdown  1: Machine Reset to startup status.   1. Press Send (Response OK should show up). |
| Example: Reset IM to 0 (shutdown) |  |

**Exception Code for Modbus Poll**

|  |  |  |
| --- | --- | --- |
| **Message** | **Cause** | **Solution** |
| No connection | No power  connection cable/adaptor issue | Check power source  Check connection cable and adaptor. |
| Response Error | Modbus Poll connection setting  connection cable/adaptor issue | Verify Modbus Poll connection setting  Check connection cable and adaptor. |
| Illegal Function(1) | Unsupported function | Verify entered value |
| Illegal data address(2) | Out of range address | Verify entered value |
| Memory Parity error (8) | Checksum failed  Cable / adaptor is too noisy | Verify Modbus Poll connection setting  Check and replace cable /adaptor |
| Timeout Error | Modbus Poll connection setting | Verify Modbus Poll connection setting |
|  |  |  |

**Digi Connect Exception**

Q: A strange file called EEEEEEEEEEEE.txt is created.

A: EEEEEEEEEEEE.txt is created because the serial Number on the Neo/KoolAire board is not set.

1. **Change Log:**

|  |  |  |
| --- | --- | --- |
| **Revision** | **Date** | **Description of Change** |
| 2 | 8/29/2011 | Added test mode and flow chart |
| 3 | 9/21/2011 | Included board communication specs. |
| 4 | 10/14/2011 | Specified Microprocessor |
| 5 | 10/17/2011 | Changed the connector for Can bus |
| 6 | 10/17/2011 | Made changes to section 3.2 |
| 7 | 11/15/2011 | Major changes to format & numbering. Added sections 2.1.7, 3.3, 3.4, 3.6 and 6.4, edited sections 2.1.4, 3.1, 6.3. |
| 8 | 12/2/2011 | Edited sections 2.1.3.1, 2.1.5, 3.1, 3.3, 3.4, 4.1, 5.6 |
| 9 | 12/19/2011 | Edited 6.3 and 6.4. |
| 10 | 1/10/2012 | Edited: 4.1-Push button test switch. Changed 6.1 and 6.6. Full bin light on interface board operates in parallel with damper switch on board. |
| 11 | 2/7/2012 | Edited sections 3.3, 6.2.4, 6.4 |
| 12 | 2/9/2012 | Edited for part names consistency, added section 3.6 |
| 13 | 4/18/2012 | Included KoolAire Specs and the gateway. |
| 14 | 4/24/2012 | Updated the cleaning sequence for KoolAire, initial start for Neo, KoolAire. |
| 15 | 6/7/2012 | Removed section 6.2.1-2. Added water inlet debounce. |
| 16 | 6/13/2012 | Agency requirements updated. |
| 17 | 7/18/2012 | Updated gateway features |
| 18 | 8/13/2012 | Updated KoolAire to UI Membrane with corresponding ice and clean sequence changes. Added modbus setting for freeze delay. |
| 18 | 8/22/2012 | Updated safety limit 1, 2, test mode. Added safety limit 3 – water loss. Fixed contents table. |
| 19 | 9/10/2012 | Updated the KoolAire back to toggle switch sequence instead of membrane UI. Updated SL3 specifics. |
| 20 | 10/4/2012 | Changed the second injection of water during freeze 7 sec (Neo) and 12 sec (KoolAire). Increased the cycle count for safety limit 3. Changed the safety limit. Added modbus test register for safety limits. |
| 21 | 10/18/2012 | Updated safety limit 3, added states in sub-topics, updated water-fill to match software. |
| 22 |  | Updated FRS to match software rev 2.28 |
| 23 |  | Added changes to clean & test mode. |
| 24 | 11/6/2012 | updated clean mode, delay mode. |
| 25 | 11/13/2012 | Added logic for power interruption to the ice machine. Ver. 2.31 |
| 26 | 1/8/2013 | Updated the Neo to start in harvest for state 1 (not used). |
| 27 | 1/15/2013 | Updated power off sequence for Neo to delay by 3 seconds, changed start- up seqeunce back to back to FRS25. Ver. 2.34 |
| 28 | 2/12/2013 | Added 6 minute max fill time for KoolAire and the DACO modbus Serial number. Changed Neo interface picture, changed float-nomenclature, format corrections. |

|  |  |  |
| --- | --- | --- |
| **Revision** | **Date** | **Description of Change** |
| 29 | 2/19/2013 | Changed the harvest seqeunce for KoolAire if the curtain is open during the freeze cycle. Section 6.2.1 updated. |
| 30 | 3/13/2013 | For KoolAire changed the sequence to add water for the circulation system, during freeze for the 120 second initial start-up. Section 6.2.4, Ver.2.40 |
| 31 | 3/20/2013 | For KoolAire and Neo bypass the 6 minute lock in for the initial freeze cycle. Change safety limit 2 –long harvest from 500 to 100 cycles, and flash the service wrench from 100 to 75 cycles. |
| 32 | 4/18/2013 | For KoolAire changed the clean mode to allow for the removal of the water curtain. Test mode Led status. Revised the modbus to read the DACO serial # for end of line testing. Initial pre-chill time on Neo changed to 2 minutes. Software V2.45-2.50 |
| 33 | 6/11/2013 | For Neo, water inlet on time on initial cycle and water inlet off time on all cycles. |
| 34 | 11/14/2014 | Changed the code name to actual models through FRS, Orca = Neo, Nevada = KoolAire. For Neo, changed the max freeze time to 45 minutes, added “pump pulse” to help reduce water slushing in the prechill cycle. Added a water assist during harvest, extending out from 3.5 to 7 minutes. Added water thaw cycle (state 10) after long harvest to help prevent freeze up. Software V2.54. |
| 35 | 12/3/2014 | Clarified the Safety limits in the in the sequence. Reset the Safety limit 2 counter after power cycle. Fixed shutting off after a SL 2/ full bin condition. Software V2.55 |
| 38 | 9/18/2015 | Section 4.6, pg. 9 added input. Section 6.2.4, pg. added pump OFF time selection based on section 4.6 input. Section 6.2.4, pg. 15 added pump OFF for 30 seconds. Section 6.2.3, pg. 14 deleted 3 seconds pump ON. Section 6.4, pg. 25 edited that delay cannot be entered while in clean. Software V2.58. |
| 39 | 04/15/2016 | Copied NEO and KoolAire FRS to D-spec. Changed format of Change Log to a table format. Removed pump pause time switch and added thermistor (Section 4.6, pg. 9). Updated Figure 3 (Section 5.6, pg. 11). Added thermistor LED (Section 6.1, pg. 12). Revised pump pause control by adding thermistor and removing jumper (Section 6.2.4, pg 15-18). Revised Safety Limit 3 during automatic restarts by shutting down after pre-chill if the harvest float is closed (Section 6.5.3, pg. 28). Added registers 25, 26 and 27 (Section 7.1, pg. 35) |
| 40 | 08/27/2017 | Per Tom Antoine and MCF testing on ORCAMCF-H1 with software version 2.60, following bugs encountered ( 5 Dec 2016)-   * During start-up cycle the harvest state is triggered by harvest float down/closed for 30 seconds – ERROR * During the second cycle the ice machine will NOT enter harvest when the harvest float is down/closed for 10 seconds or 30 seconds, resulting in 45 minute freeze time – ERROR   Above bugs fixed with below resolution under software test version 2.701.   * Harvest state should trigger after 10 seconds * Ice maker should enter harvest state when harvest float is down/closed for 10 seconds, this can occur at any point in the start-up cycle and any time after 6 minutes in subsequent cycles   ( See FRS section 6.2.4 Freeze Cycle: Freeze Lock-in time , page 18)  MII and MCF regression tested 2.701 to verify if bugs are fixed and software works per FRS.  MII and MCF recommended to release test software version 2.701 as production software for ORCA NEO.  Production software version will be 2.70. |
|  |  |  |