

# OPERATOR'S GUIDE TO ENERGY EFFICIENT INDOOR PUBLIC POOL OPERATIONS

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## SUMMARY

### Purpose

This guide outlines for you, as a pool technician, the most important steps you can take to optimize the energy use in your public pool facility in Minnesota. It outlines 15 operational checks that identify no-cost and moderate-cost changes that on-site staff and/or a contractor can make without major equipment upgrades. It also points out a few situations where more expertise and/or a little higher investment might be required to take advantage of an energy cost saving opportunity or to solve a problem. The recommended actions are conservative to ensure that pool and space conditions are not negatively impacted.

You can apply this guide independently, or with the support of a utility-funded Conservation Improvement Program (CIP). Some operational checks could lead to the implementation of items that are eligible for traditional utility equipment rebates, for example the installation of a variable speed drive on the pool pump. Other items may be rebated through a utility recommissioning program (e.g. fixing a control programming issue that causes excess energy use), behavior change program, operator training program, or other progressive program design.

### Scope

The focus is on key actions that you as a pool operator and/or HVAC technician can take to identify and implement energy saving measures that require no or moderate capital cost. It is not intended to systematically address water quality, air quality, or moisture condensation issues. It does not address all upgrades that might be identified through a

comprehensive engineering evaluation of a facility—especially those involving major upgrades or replacement of equipment.

In addition, this guide does not fully address operations related to water filtration and water treatment, which can impact energy use. This specialty subject is already addressed by numerous other resources, including the pool operators manuals listed on the next page.

### How to Use the Guide

Portions of this guide can yield energy savings from just a one-time use; however, you will most effectively achieve long-term energy savings, comfort, and minimal moisture condensation issues if: (1) all applicable checks are conducted for a facility, and (2) a number of the individual checks are incorporated into the facility's regular schedule of operations and maintenance procedures.

While each check is individually worthwhile and written as a stand-alone item, there is a level of interdependence that makes completion of all applicable items significantly more effective. It is recommended that you follow these steps:

1. Systematically go through the guide to determine the applicability of each item for your facility.
2. Conduct all applicable checks at least one time.
3. Follow through on the energy cost saving actions identified through the completion of the checks.
4. Repeat select checks seasonally based on the recommended frequency and implement any subsequent energy saving actions identified.

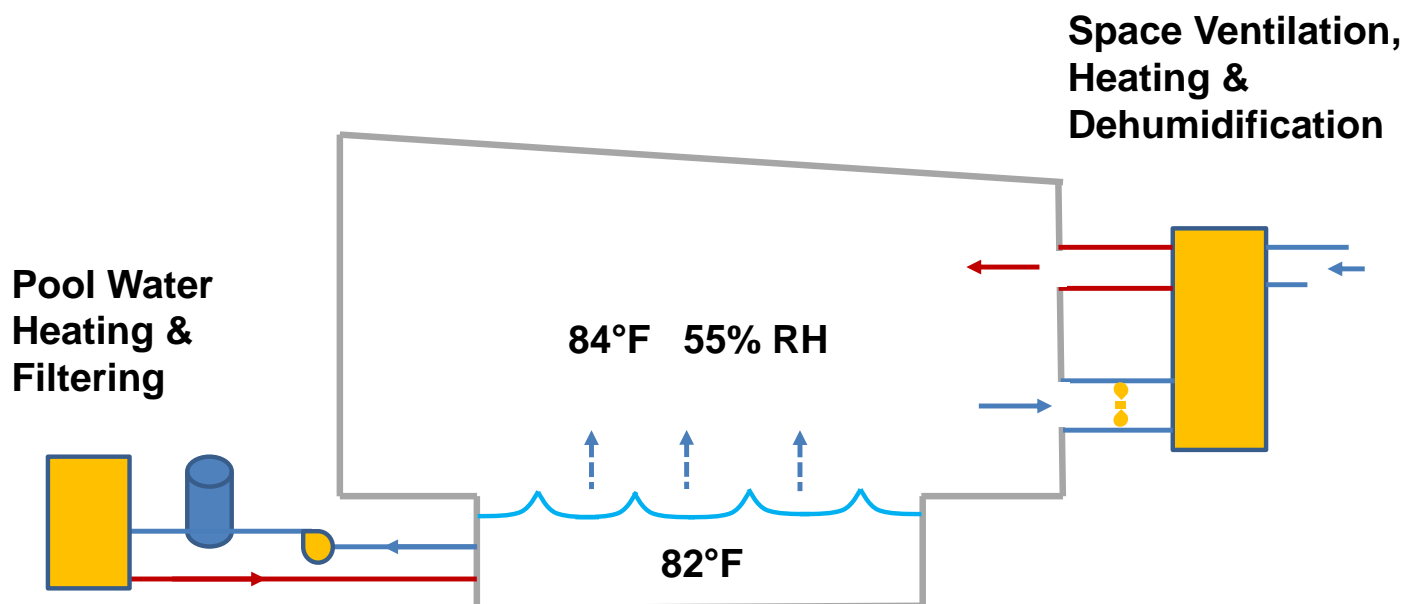
The checklist on the following page gives a summary of the 14 items to be checked. The detail column in the table notes if and where more information is available for the item. For selected checks, detailed instructions are included in the following sections, and a two character letter and number code is noted to help you locate these instructions. In some instances the instructions refer to reference documents that are noted in the last section of the guide and that will be helpful for some operators. However, for most of the checks, you will probably be able to rely on the checklist and the instructions/key reminders included in this guide.

### Pool Systems Summary

Indoor pool facilities have energy intensive, specialized conditioning requirements, but in practice equipment is often not operated and maintained in a way that is optimal with respect to energy performance. Optimized operation of these facilities requires careful

balancing between pool temperature and the combination of air temperature and humidity. Modest changes in any one of these can throw off the balance and have large energy and comfort impacts. The key system components in a public pool facility are illustrated in the figure below. There are a number of other ways that excessive energy use can be caused by HVAC equipment operational problems that may easily go unnoticed. The control systems for HVAC systems for swimming pool areas compensate for many problems by using excessive energy without the pool temperature and space conditions being affected. Two common problems that are not “self-alerting” include using excessive amounts of outside air and the failure of heat-recovery equipment. The achievable cost-effective savings potential is significant because of the combination of the number of facilities, energy-intensity, and sensitivity of energy use to a number of maintenance and operations issues.

### Diagram of Key Pool Area Equipment



# Energy Efficient Pool Operations Checklist

Check	Frequency	How It Saves Energy	Detail
<b>Settings &amp; Sensors</b>			
<b>Optimal Relative Humidity</b>	Every 2 Months	Keeping the humidity lower than necessary increases the evaporation rate and the energy usage of the dehumidifier.	<a href="#">S1</a>
<b>Confirm Humidity Sensor Accuracy</b>	Quarterly	Humidity sensors tend to fail quickly, causing either unnecessary dehumidifier operation or poor humidity control.	<a href="#">S2</a>
<b>Optimal Pool Water Temperature</b>	Monthly	Overheating the pool increases the pool evaporation rate, heating energy and dehumidification needs. Lowering it within the comfort range prevents this.	NSPF, Ch.12 NRPA, 10-3
<b>Optimal Space Temperature</b>	Quarterly	Overheating the pool area air above the pool water temperature causes excess air heating and evaporation. Reducing the air temperature within the comfort range prevents this.	NSPF, Ch.12 NRPA, 20-5
<b>HVAC Checks</b>			
<b>Seasonal HVAC Operation</b>	Quarterly (except summer)	Control problems can lead to over active dehumidification with excess energy use and equipment wear.	<a href="#">H1</a>
<b>Energy Recovery Ventilator</b>	Quarterly (except summer)	Where an ERV is present, improper control or breakdown can eliminate any energy cost savings, typically without any change in space conditions that would draw attention to the issue.	<a href="#">H2</a>
<b>Outdoor Air Ventilation</b>	Quarterly (except summer)	Bringing in too much outdoor air increases energy costs, while bring in too little air can cause air quality problems and excessive dehumidifier operation.	<a href="#">H3</a>
<b>Main Heat Source</b>	Semi-Annually (except summer)	In complex units, if something goes wrong with the main heat source, another source will compensate but often with added energy costs, extra equipment wear, and/or poor space control.	-
<b>Water Side</b>			
<b>Use Of Pool Cover</b>	Daily	Covering an unused pool to prevent evaporation is a large energy saving opportunity; the use of a liquid pool cover may also provide savings (although not as much).	NSPF, Ch.12 NRPA, 10-5
<b>Main Valve Throttling</b>	Annually	Optimizing of pumps is often compensated for by choking down the flow, and this uses more energy than just slowing down the pump.	<a href="#">W1</a>
<b>Pool Filter Flow</b>	Annually	Turning the pool over faster than the required 6 hour time frame required for most pools increases pump energy use.	NSPF, Ch.10, Ch.11 NRPA, Ch.5, Ch.8, Ch. 9
<b>Seasonal Boiler Switchover</b>	Seasonally	If you have a small boiler/pool heating that is used only in mild weather (while a central boiler is shut down) it is often more efficient than the central boiler. If so, using the seasonal system longer may provide large savings.	-
<b>Minimum Draining Of Heated Water</b>	Annually For Each Operator	Heating of fresh make-up water requires significant energy. Avoid excessive filter backwashing or draining more than needed to control TDS levels.	NSPF, Ch.6, 7, and 11 NRPA, Ch. 8
<b>Pool Water Heat Source</b>	Semi-Annually	Long-term pool water heater underperformance can be masked by overheating of the air above the pool, which leads to excessive heating energy use.	NRPA, 10-2,3
<b>Over Heating During Water Fill</b>	Each Long Fill Event	If fresh, cold water is added upstream of the heater's control sensor for 5+ minutes, then significant overheating of the pool can occur. Temporarily disabling heater can prevent this.	-

\*The items with black text have a more detailed check description within this document, while those with dark gray text do not.

## INDIVIDUAL ITEM CHECKS

For those checks on the checklist that have a single letter and single number code in the detail column, a detailed check with that letter-number code can be found in this section. These specific items were chosen because of their significant potential energy impact and/or a lack of clear direction in other readily available resources. For a number of other checks, the checklist refers you to specific parts of the two most prominent pool operator training manuals. These documents are:

- NSPF: National Swimming Foundation, Pool & Spa Operator Handbook, 2012 - 2017 Editions.
- NRPA: National Recreation and Park Association, Aquatic Facility Operator Manual, Revised 6th Edition.

Also note that the checks are broken down into the three categories described below.

### Settings and Sensors

Suboptimal control settings and/or inaccurate sensors commonly cause pool systems to use more energy than needed and lead to occupant discomfort. The checks in this section outline a few steps you can take to ensure that the pool and space are maintained at the temperatures/humidity required to achieve comfort levels, without excess energy use. With the exception of checking pool water temperature more frequently, these checks generally only need to be once every two or three months. Detailed guidance is outlined in this guide for the following checks:

- [S1. Optimal Relative Humidity](#) .....Page 5
- [S2. Confirm Humidity Sensor Accuracy](#) .....Page 9

### HVAC Operations Checks

Through the observation of basic operations, without the use of expensive test equipment or a high level of expertise, you can identify many suboptimal conditions that unnecessarily increase energy use. Performance of the HVAC operations checks will effectively screen for a large percentage of the issues that lead to artificially high HVAC system energy use in indoor public pool facilities. Most of these are recommended for completion every two or three months. Detailed guidance is outlined in this guide for the following checks:

- [H1. Seasonal HVAC Operation](#) .....Page 13
- [H2. Energy Recovery Ventilator Basic Check](#).....Page 16
- [H3. Outdoor Air Ventilation Rough Check](#).....Page 20

### Water Side Operation Procedures

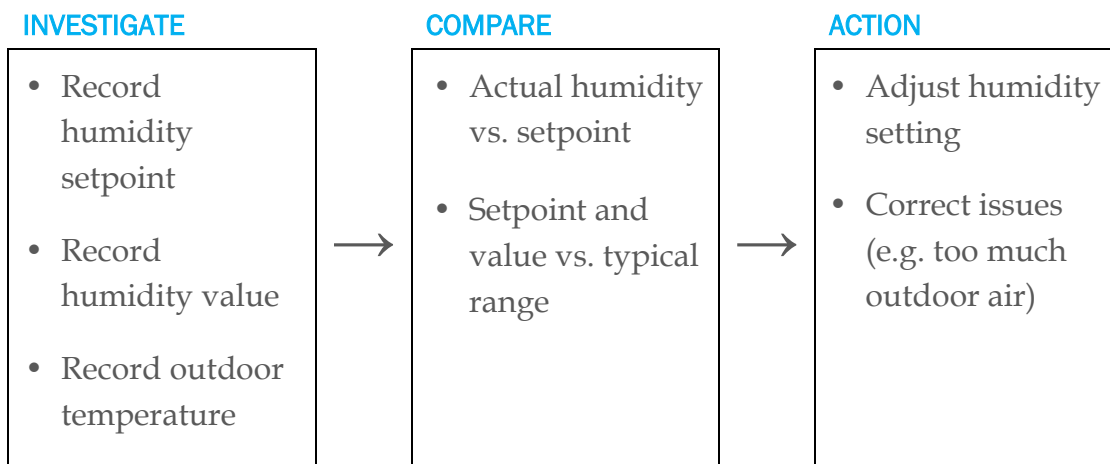
A number of practices, procedures, and checks in this category often lead to more efficient operation of a facility without upgrading equipment. Some of these require no capital cost, while others identify problems that may require some capital cost to correct, but will give a quick payback. A couple of these items may require changes to regular operating procedures. However, most of these items don't need to be checked often. Detailed guidance is outlined in this guide for the following check:

- [W1. Main Valve Throttling](#) .....Page 23

# S1. Optimal Relative Humidity

While too high of humidity at the wrong time can cause familiar condensation problems, being too aggressive at maintaining a low humidity can also significantly increase energy use and make it feel uncomfortably cold for swimmers after they exit the water. Also, humidity far above or below the setpoint can be a symptom of a problem that is preventing the HVAC system from performing as intended or performing in a way that uses more energy than necessary.

## WHEN TO CHECK: EVERY 2 MONTHS



### INVESTIGATE

Record Humidity Setpoint \_\_\_\_\_% RH

- Depending on the unit and controls arrangement, the humidity sensor display may be accessible at a few different locations.
- Often the humidity setpoint is accessed either through a control display at the HVAC unit itself, on a control device attached to the return duct, or through a Building Automation System (BAS) interface.
- Sometimes, a thermostat-like device in the pool room has an accessible setpoint, although there would typically be a locking cover, or some other way to limit access. If a device in the pool room displays humidity but does not have arrow buttons, a dial, or a lever for adjusting, it is probably only displaying the current value and is **not** displaying the setpoint.

Record Actual Humidity Value \_\_\_\_\_% RH

- Depending on the unit and controls arrangement, the current sensor reading may be accessible at a few different locations.
- Often the current reading for the humidity sensor is visible either through a control display at the HVAC unit itself, on a control device attached to the return duct, or through a BAS interface.

- Sometimes, a thermostat-like device in the pool room has a display that shows the current humidity. If a device in the pool room has arrow buttons, a dial, or a lever for adjustment, it may display the setpoint instead of (or in addition to) the current sensor reading. If so, look carefully to be sure that you do not confuse the RH setpoint for the current value.

#### Record Outdoor Temperature \_\_\_\_\_ °F

- Outdoor temperature can be measured on-site via a BAS sensor or thermometer (in the shade)
- Or, you can use a cell phone app (or website) to get a current nearby weather station reading.

### COMPARE

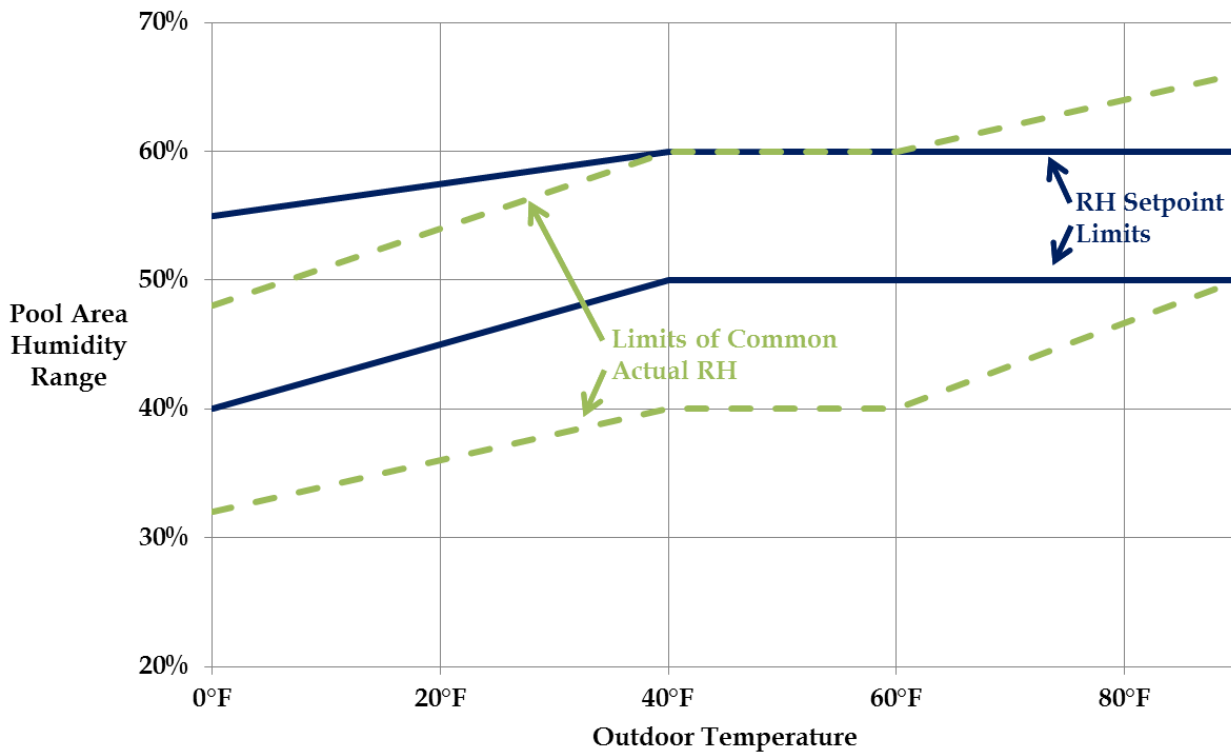
#### If the RH Setpoint and RH Value Differ by More Than 6%

- If there's no compressor, the RH is above setpoint, and it's above 60°F outside, the unit may be functioning as designed, but it has a limited ability to maintain a RH well below 60% in warm weather. If the HVAC unit is bringing in its maximum possible outdoor air (see [H1](#) for more information), then no action is needed to address this discrepancy.
- If the RH is above setpoint and it's above 75°F outside, the unit may be functioning as designed, but it has a limited ability to maintain a RH well below 60% in hot, humid weather. If the dehumidifier appears to be operating at its maximum capacity (see [H1](#) for more information), then no action is needed to address this discrepancy.
- If the RH is below setpoint and it's below 50°F outside, the unit may be functioning as designed, but the dry outdoor air needed for air quality reasons is providing more inadvertent dehumidification than is needed. If the HVAC unit is not trying to dehumidify (see [H1](#) for more information), then no action is needed to address this discrepancy.
- If the RH is well above or below setpoint under other circumstances, take the associated steps noted in the action list for this check.

#### Typical Humidity Control Chart

- The chart shows the typical range of pool area relative humidity setpoints and actual values.
- The solid, dark blue lines show the suggested range of RH setpoint.
- The dashed green lines show the range of actual RH values that are somewhat common to see.
- The higher observed humidity levels at high outdoor temperatures tend to occur for outdoor air only dehumidifier systems. HVAC units with cooling coils and/or desiccant dehumidification tend to control the humidity better at these extreme conditions.

### Typical Relative Humidity Ranges



### Compare Humidity Setting and Value to Chart Ranges

- Setting the HVAC unit to provide a lower humidity than suggested by the “setpoint” range significantly increases energy use, pool water evaporation, and wear on any compressors. This should only be done to the extent that site-specific experience has shown a need to do so to prevent condensation problems. Note that condensation problems are far worse in very cold weather, when the inside part of exterior surfaces can get cooled below the dew point of the humid, pool room air. So higher a RH setpoint during mild winter weather may be fine in a facility that needs lower humidity in very cold weather to prevent condensation problems. If a setpoint is unnecessarily below the suggested range, see the associated action.
- Humidity setpoints above the range are not recommended due to the likelihood of condensation and/or comfort issues. If a setpoint is unnecessarily above the suggested range, see the associated action.
- Actual RH values below the range shown suggest that there may be more outdoor air ventilation than is needed. Take the associated action to investigate and correct if needed.
- Actual RH values above the range shown suggest that there may be less than the needed amount of outdoor air ventilation. Take the associated action to investigate and correct if needed.

## ACTION

### If Direction to Action for RH Setpoint versus Value Discrepancy

- To degree to which it is possible, check on dehumidifier operation (see [H1](#) for more information) to see the extent to which it is actively trying to dehumidify.
- If the RH is above setpoint **and**:
  - If the HVAC unit is not trying to dehumidify as much as possible, then a qualified technician should inspect for what is probably a controls issue; **or**
  - If the unit is trying to dehumidify as much as possible under conditions for which it is expected to keep up, then a qualified technician should inspect for what is probably an equipment issue.
- If the RH is below setpoint **and**:
  - If the HVAC unit is not trying to dehumidify, check for excessive outdoor air; **or**
  - If the unit is still trying to dehumidify when it is not needed, a qualified technician should inspect for what is probably a controls issue.

### If Directed to Action for a RH Setpoint Outside of Suggested Range

- Change the setpoint to a value within the suggested range.
- If the setpoint control is right on the unit or a thermostat like device, it will probably have a fixed setpoint. This may need to be manually changed seasonally to get the optimal balance between comfort, energy use, and condensation.
- Many BAS (and some stand-alone controllers) will have the capability to automatically adjust the relative humidity setpoint in response to outdoor air temperature. If so, this will probably provide the best approach. However, note that the control logic should be verified as much as possible to confirming the proper setpoint on displays and that such automatic control is also susceptible to any errors in the outdoor sensor readings and should also be checked periodically.

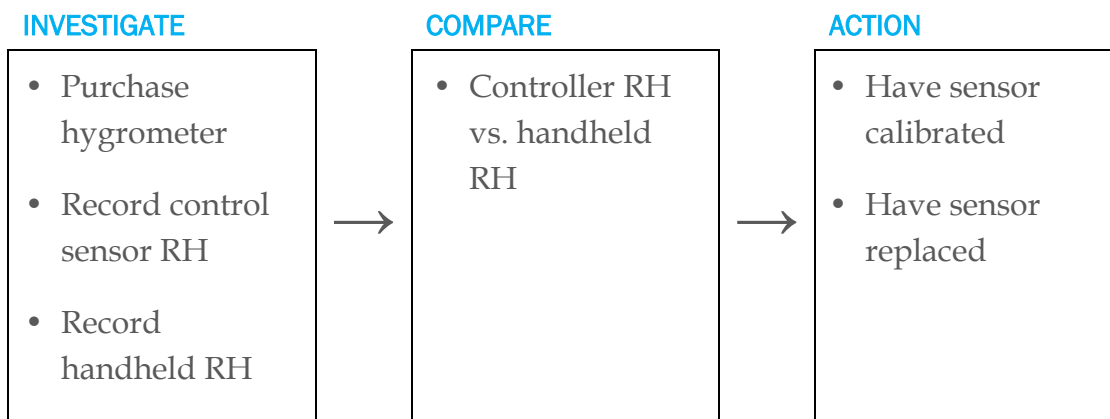
### If Directed to Action for an Actual RH Value Below Expected Range

- Check for excessive or inadequate outdoor air by first seeing if a motor-driven outdoor air damper has a problem with the actuator or linkage that is causing it to be open or closed farther than it should be based on the expected control. If so, have this corrected by a qualified technician.
- If the outdoor airflow is a fixed value or at its expected value, it is suggested that the airflow be checked by someone who is qualified to assess the desired minimum outdoor air ventilation rate and measure the actual outdoor airflow rate. If outdoor air ventilation is found to be significantly above or below the amount needed, have it corrected.

## S2. Confirm Humidity Sensor Accuracy

Relative humidity sensors are notorious for failing and leading to control problems. For pool areas humidity control is more critical than in many other situations, and the presence of chloramines and high humidity make humidity sensor life even more problematic in pool systems. This check gives detailed guidance on how you should regularly confirm the accuracy of the humidity sensor used to control the pool dehumidifier.

### WHEN TO CHECK: QUARTERLY



### INVESTIGATE

#### Obtain and Maintain Hygrometer (i.e. Relative Humidity Meter)

- A handheld hygrometer that measures RH with an accuracy of  $\pm 3\%$  can be purchased from many different industrial suppliers or retail suppliers for less than \$150. If the pool area's humidity sensor has a case that can hold up a small desktop type hygrometer, the price may be even lower.<sup>1</sup>
- DO NOT STORE THE HYGROMETER IN THE POOL EQUIPMENT ROOM. Doing so would greatly accelerate the failure of this meter. It is best stored in a conditioned indoor environment that does not experience extremely high humidity levels.
- The accuracy of the handheld hygrometer should be checked periodically. A convenient way to get a rough confirmation of a handheld hygrometer is against a nearby weather station reading obtained from a website, news report, or mobile phone app. Don't do this comparison if the outdoor RH is below 15% or above 80%. Also note that the RH reading is dependent on temperature, so this comparison will only give a close match if the meter's temperature reading is within 2°F to 3°F of the weather station temperature.

<sup>1</sup> A hand-held sling psychrometer is a moderately lower cost alternative that will not need to be calibrated. During each use of a sling psychrometer, the sock on a wet-bulb thermometer must be wetted and the thermometers must be spun for a few minutes until the wet-bulb temperature stops going down. Then the relative humidity is found from the wet-bulb temperature and a dry-bulb temperature (on the same device) using a slide rule that is on the psychrometer, or that comes in the same package.

Also note that site-specific conditions (e.g. sunny versus cloudy or a nearby lake) can cause discrepancies between the weather station and the handheld hygrometer.

**Record Handheld Hygrometer Humidity and Temperature Values \_\_\_\_\_% RH \_\_\_\_\_°F**

- The dehumidifier will have a humidity sensor either in the pool room itself or within the ductwork that returns air from the pool room to the HVAC unit. If the sensor is in the room itself, measure the RH right where the sensor is located. If the control sensor is in the return duct, hold the handheld sensor as close to the return grill as possible. (Although return grills are often near the ceiling so you may not be able to get very close.)
- Note that humidity sensors can be sensitive to temperature or RH fluctuations caused by your breathing or body heat. Take care to avoid breathing on the device and whenever possible stand at arm's length while taking the reading.
- If there is a convenient and safe place to set the portable hygrometer on top of the control sensor case, set it there for at least five minutes before taking a reading. If that's not possible, hold the portable device as close to the control sensor as possible and wait at least two minutes to record the values. If either the RH or temperature are still changing every few seconds, wait until they are both steady (being careful to breath away from the sensor).

**Record Control Sensor Humidity and Temperature Values \_\_\_\_\_% RH \_\_\_\_\_°F**

- Take the control sensor readings as soon as possible after taking the handheld meter readings.
- Depending on the unit and controls arrangement, the current sensor reading may be accessible at a few different locations.
- Often the humidity sensor is visible through a control display at the HVAC unit itself, either on a control device attached to the return duct or through a BAS interface.
- Sometimes, a thermostat-like device in the pool room has a display that shows the current humidity. If a device in the pool room has arrow buttons, a dial, or a lever for adjustment, it may display the setpoint instead of (or in addition to) the current sensor reading. If so, look carefully to be sure that you don't confuse the RH setpoint for the current value.
- Humidity sensors can be sensitive to temperature or RH fluctuations caused by your breath or body heat. If you are taking a reading directly from the display of a thermostat-like device in the pool room, take care to avoid breathing on the device and whenever possible stand at arm's length while taking the reading.

**COMPARE**

**Put Inputs into RH Comparison Calculations Below**

- Enter the temperature and RH measurements you recorded above into the blanks by the blue highlighted labels in the first calculation table below.

- Use the control sensor RH value to find the “adjustment factor” from the calculation table on the right hand side. Enter this “adjustment factor” into the calculation in the blank below the orange highlighted label.

#### Perform the Calculations as Laid Out

- Be careful to carry and negative (minus) sign from one box to the next. If both numbers being multiplied together are negative, the adjustment value will be positive.
- An example calculation appears immediately after the blank calculation table.

#### Compare Adjusted Handheld RH to Control Sensor RH (Two Value on Bottom Row)

- If there is less than a 5% discrepancy, no action is needed.
- If there is a 5% to 8% discrepancy, you should consider checking again soon and making the seasonal dehumidifier operation check to see if it contributes to unusual control.
- If the discrepancy is more than 8%, take action as noted in the next subsection.

### Humidity Comparison Calculations

Control Sensor Temp	°F	Adjustment Factor		
Handheld Temp	— °F	(From Table)		Adjustment
	= ± °F	X — % per °F	=	± %

Handheld RH	%	Control Sensor RH	
Adjustment	± %		
Adjusted Handheld RH	= %	VS	%

Control Sensor RH	Adjustment Factor
< 40%	-1 % per °F
40 - 50%	-1.5 % per °F
> 50%	-2 % per °F

### Sample Humidity Comparison Calculations

Control Sensor Temp	84 °F	Adjustment Factor		
Handheld Temp	— 81 °F	(From Table)		Adjustment
	= 3 °F	X -1.5 % per °F	=	-4.5 %

Handheld RH	54 %	Control Sensor RH	
Adjustment	± -4.5 %		
Adjusted Handheld RH	= 49.5 %	VS	48 %

### ACTION

#### If >20% - 25% discrepancy

- Replace the humidity sensor.
- Adjust control setting to compensate in the meantime

#### If 15% - 25% discrepancy

- Calibrate or replace the humidity sensor.
- Adjust control setting to compensate in the meantime
- Repeat checks on this sensor more often than the typical frequency.

#### If 8% - 15% discrepancy

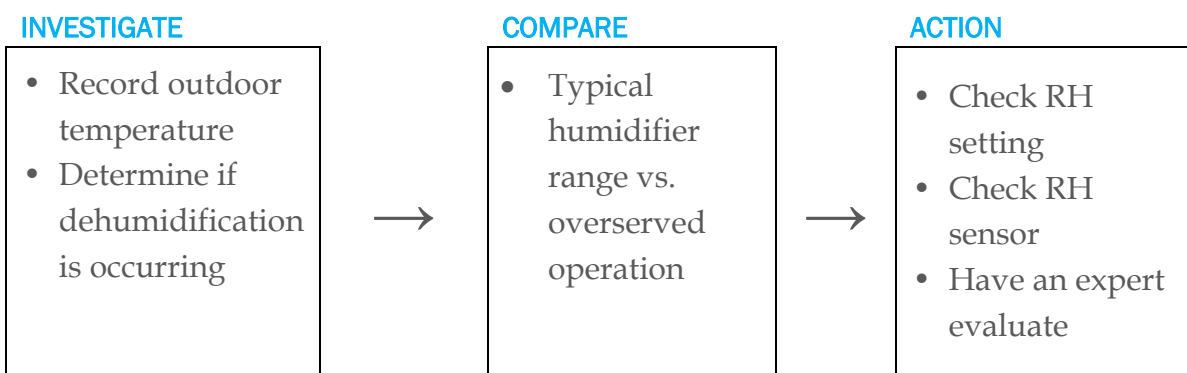
- Have the humidity sensor calibrated.
- Adjust control setting to compensate in the meantime

- Repeat checks on this sensor more often than the typical frequency.

# H1. Seasonal HVAC Operation

Indoor public pool facilities in Minnesota get adequate “free” dehumidification much of the year. This is because a certain amount of outdoor air must be continuously circulated through the pool area to keep the air fresh, and for most of the year the outdoor air is much dryer than the humid pool area air. Some HVAC systems dehumidify a pool area by simply bringing in enough dry, out outdoor air to keep the indoor humidity in check, while others use air conditioning compressors to cool and then reheat the air. Whichever, approach is used, excessive operation of the dehumidifier in cool (dry air) weather can cause both excessive energy use and accelerated deterioration of the dehumidifier. Here’s how to check for this excessive operation.

## WHEN TO CHECK: QUARTERLY (EXCEPT IN THE SUMMER)



### INVESTIGATE

#### When to Measure

- It’s best to check when there hasn’t been unusual activities that increase load.
- Wait until at least two hours after unusually high activity levels to do your check.

#### Record Outdoor Temperature \_\_\_\_\_ °F

- Outdoor temperature can be measured with a BAS sensor or thermometer (in the shade)
- Or, you can use a cell phone app (or website) to get a nearby weather station reading.
- If dehumidifier operation is monitored over a period of time, record the outdoor temperature periodically (being sure to get a high and low reading).

#### Record HVAC Operation Status

- For systems with variable outdoor air dampers, observe outdoor and return air dampers. Outdoor Air \_\_\_\_\_% open; Return Air \_\_\_\_\_% open and/or exhaust fan variable speed drive (if it has) \_\_\_\_\_Hz ÷ 60 Hz = \_\_\_\_\_% speed
- For systems with compressors, observe which compressor(s) run and roughly the percentage of time that they run [see compressor observation tips].  
#1 \_\_\_\_\_% on; #2 \_\_\_\_\_% on; #3 \_\_\_\_\_% on; #4 \_\_\_\_\_% on

## COMPARE

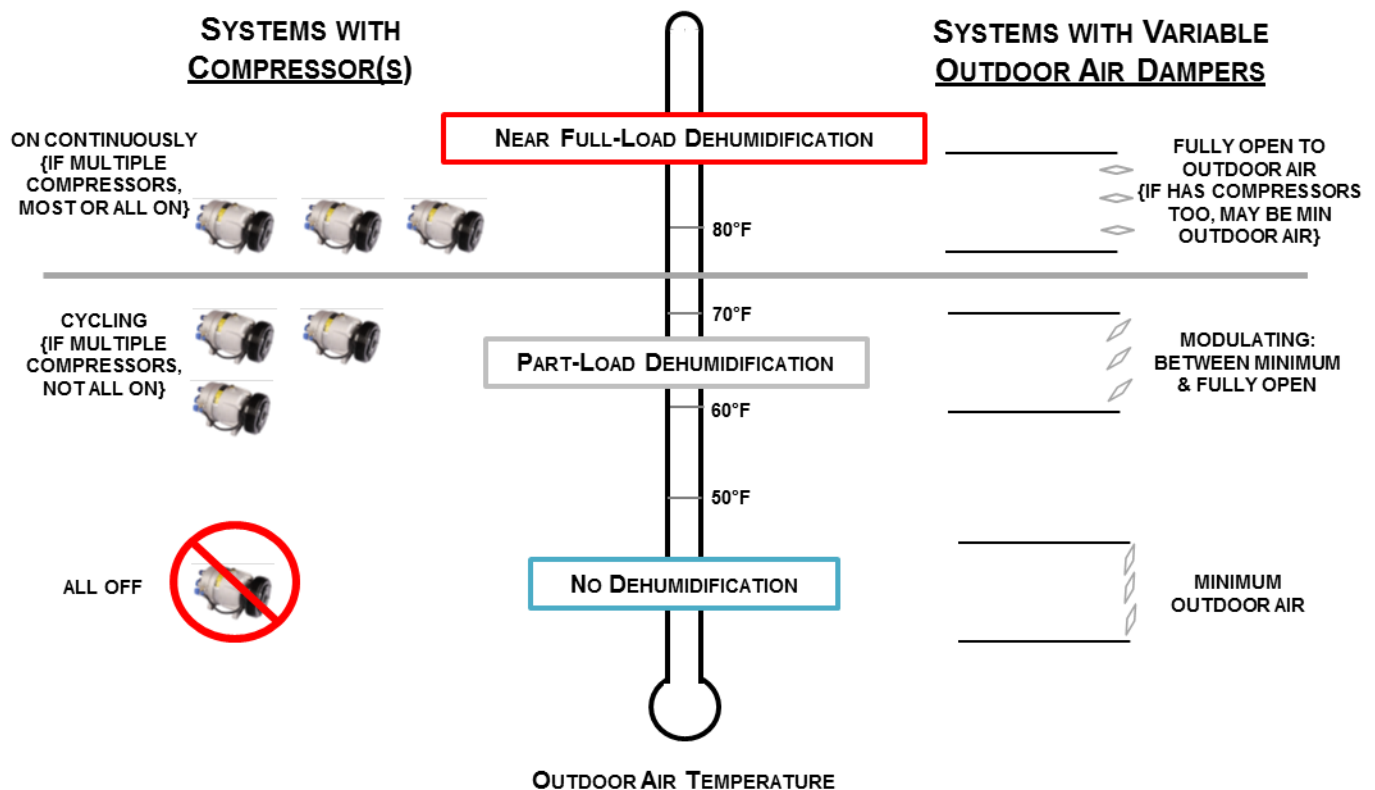
### Typical Dehumidifier Operation Chart (below)

- The chart shows how the typical dehumidifier load varies seasonally in Minnesota, where the fresh outdoor air needed for ventilation is cold and very dry in the winter, but carries in more moisture in warmer weather.
- Dehumidifiers that use compressors are represented on the left. [See "[Compressor Observation Tips](#)" for more information about how to know if a compressor is running or cycling.]
- Dehumidifiers that vary the outdoor airflow to dehumidify are represented on the right.

### Compare Actual Dehumidifier Operation to Chart

- Does the actual compressor/outdoor air match chart closely? **Okay as is.**
- Is the actual compressor/outdoor air > chart (or <)? **Take Action to save**
- If Outdoor Air % Open + Return Air % Open  $\neq$  100% ( $\pm 20\%$ ) **Take Action to save**

### Typical Dehumidification Operation Chart



## ACTION

### Check Humidity Control Settings [see [S1](#)]

- If it's lower than it needs to be, adjust and repeat observations to confirm reduced dehumidifier operation.
- If it checks out okay, continue on to the next action on the list.

### Check the Humidity Sensor for Accuracy [see [S2](#)]

- If it's inaccurate, replace and repeat observations to confirm reduced dehumidifier operation
- If it checks out okay, continue on to the next action on the list.

### Have an Expert Evaluate the System for Other Issues and Solutions Such As:

- Not enough outdoor air to ensure good air quality.
- Minimum outdoor air is too high (likely if compressor runs much less than chart).
- Damper actuator failure.
- Suboptimal control sequencing.

#### SAMPLE OF SAVINGS — FITNESS CENTER

**\$20,700 PER YEAR**

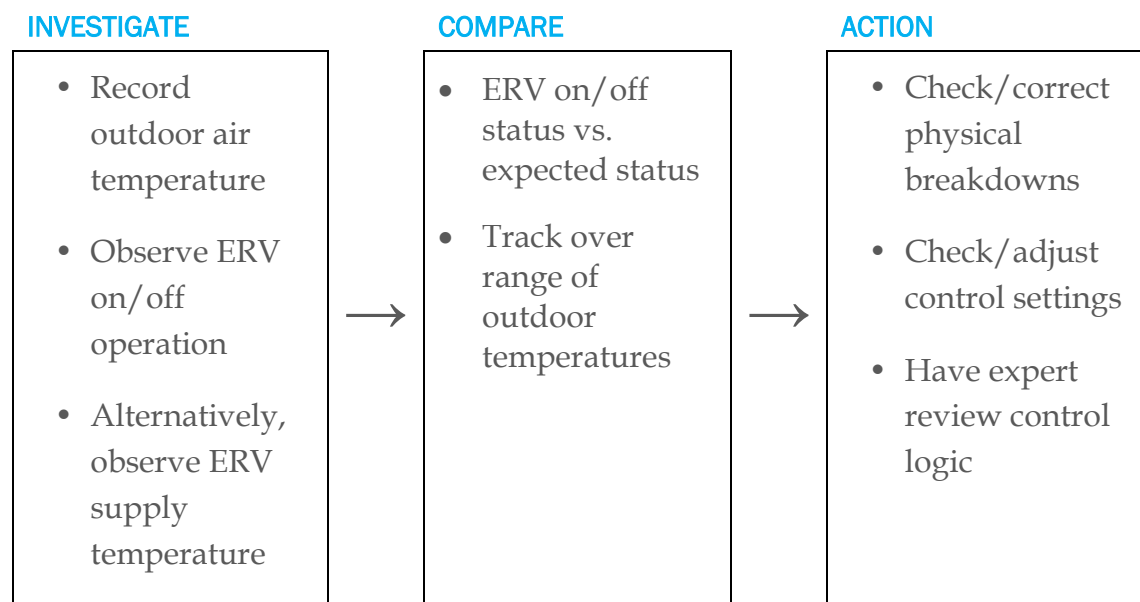


One fitness center had poor control of the hot water heating coil that caused the compressor to run continuously in the winter for heating purposes. Besides dramatically increasing the energy costs, this was causing the compressor to fail an average of every two years at a replacement cost of \$30,000.

## H2. Energy Recovery Ventilator Basic Check

Energy recovery ventilators (ERV) provide dramatic energy cost savings for public pool facilities because of the need for high continuous outdoor air ventilation rates. When present, ensuring proper operation of an ERV is typically the most important energy saving check. This is because, although they have a dramatic impact on energy use, their failure usually doesn't cause any other adverse effects that would alert an operator of a problem. Another heating source typically picks up the slack without there being any impact on pool room conditions. This check outlines how you can quickly confirm that an ERV is operating as intended.

### WHEN TO CHECK: QUARTERLY (EXCEPT IN THE SUMMER)



### INVESTIGATE

Record Outdoor temperature \_\_\_\_\_ °F

- This can be measured on-site via a BAS sensor or thermometer (in the shade), or you can use a cell phone app (or website) to get a current nearby weather station reading.

Fixed Plate ERV Face and Bypass Damper Control \_\_\_\_\_ On (face) or Off (bypass)

- Fixed plate ERV units turn the heat recovery "on" or "off" by having air flow through the heat exchanger (i.e. face) or around the heat exchanger through an alternative airflow path (i.e. bypass). When an ERV is "on," the face damper is open to allow air to flow through the heat exchanger, and the bypass damper is closed.
- The face/bypass damper arrangement is usually on only one air stream – either the fresh outdoor air stream or the exhaust air stream.
- Some systems will vary the ERV capacity with an "on" condition that allows a portion of airflow through both the face and bypass dampers at the same time. If this is observed, record: \_\_\_\_\_% open to heat exchanger and \_\_\_\_\_% open to bypass.

- BAS displays will often have a graphic that notes the intended damper position. While this can provide a good indication of the intended control, it is recommended that you make a direct observation of the dampers to the degree that this is possible. On some systems, opening a specific panel will provide a clear view of damper positions. Clear indications of damper positions might also be possible by looking at the damper actuator and linkage assembly.

#### **Recovery Wheel Control \_ On (Wheel Spinning) or Off (Wheel is Still)**

- Systems with wheels for recovering energy turn “on” or “off” by having the recovery wheel rotate or not. Complex systems may even vary the wheel rotation speed instead of having it simply on or off. If the control system displays a wheel speed, record that here: \_\_\_\_\_ wheel speed as % of maximum.
- BAS displays will often have a graphic that notes the intended damper position. While this can provide a good indication of the intended control, it is recommended that you make a direct observation of the wheel itself to confirm that it is actually rotating or not.

#### **Alternative ERV Recovery Status Observation      On or Off**

- If direct observation of the face/bypass or recovery wheel operation is not possible, it is sometimes possible to get a good indication of its operation status by looking at a BAS or control panel readout of the preheated (or precooled if in hot summer weather) air temperature after the recovery section and before any other heating or cooling coils.
- It is typically possible to get a BAS readout on a “preheated” temperature for recovery wheel units. However, this is often not possible on plate ERV units because a true indication of the preheated temperature for plate ERV units can only be observed after the face and bypass airflows mix together. Many units have a heating or cooling coil immediately after the heat exchanger and this changes the air temperature before the face and bypass flows mix back together. Any heating or cooling provided by this coil makes it impossible to get a true “preheated” air temperature that is a representative average of all of the fresh outdoor air coming through the unit.
- Where a representative “preheated” air temperature is available, you can tell the ERV’s on/off status by comparing this temperature to the outdoor and pool room temperatures. If the “preheated” air temperature is closer to the pool room than to the outdoor temperature, the ERV is “on.” If the “preheated” temperature is closer to the outdoor temperature, then the ERV is “off” or operating at a reduced capacity

### **COMPARE**

#### **Typical ERV On/Off Operation Ranges**

- The next figure shows when a pool ERV should be “on” or “off”.
- While the ideal exact transition points will vary somewhat based on site and equipment specific details, operation that is clearly inconsistent with this should be addressed.

#### **ERV On Ranges**

- During most cold weather periods and very hot weather periods the ERV should be operating to preheat or precool the outdoor air. The energy savings that can be achieved

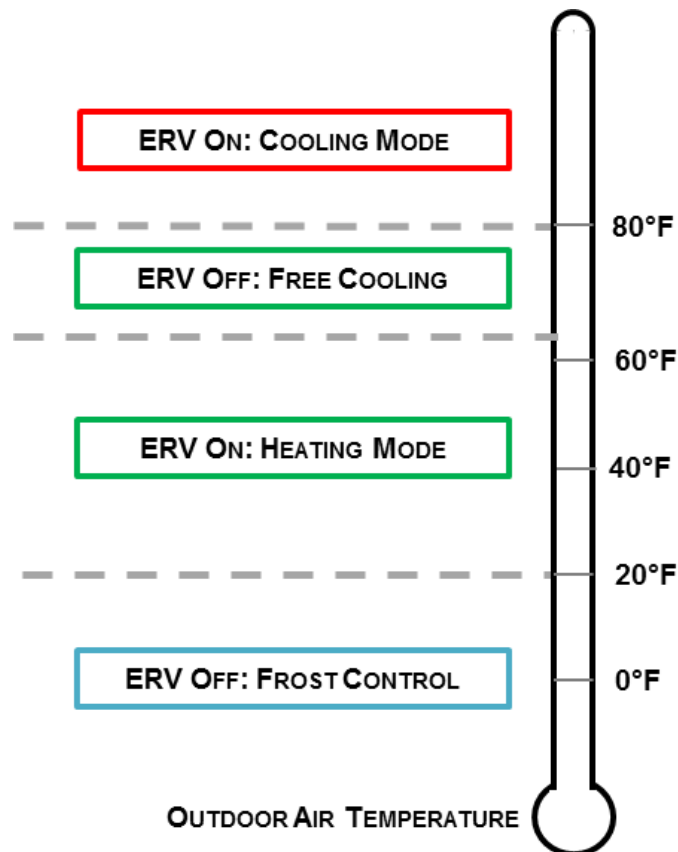
by operating during these time periods is the reason that an ERV is installed. If there is significant ERV “off” status in these ranges, take action to correct this.

- Depending on the HVAC unit arrangement, a failure of the ERV to operate in cooling mode can cause comfort problems with either the humidity or temperature drifting up beyond the desired range, and action should be taken to address this.

### ERV Off Ranges

- Significant operation of the ERV in the “ERV Off: Frost Control” range could lead to problems with icing up of the ERV that cause damage, prevent adequate ventilation, or greatly reduce the ability of the unit to recover heat. Some units will vary the capacity in this range to allow for some heat recovery without frost problems. In either case, watch for ice build-up and take action to correct if there are signs of frosting.
- The “ERV Off: Free Cooling” zone of operation is more variable based on site and system details. If the ERV is “on” in this area, it is not necessarily a sign of a problem. The possible drawback is overheating, which could either cause the pool room to be warmer than desired or cause extra compressor use for cooling. If either of these issues is suspected see “Have Control Evaluated By and Expert” section within the action items.

Typical ERV On/Off Operation Ranges



## ACTION

### Check for Physical Malfunctions

- For fixed-plate ERVs, check that ERV face and bypass damper linkages are all securely attached and that there are no visible problems with the damper assemblies. As necessary, have an expert evaluate damper actuators and linkages.
- For wheel-type ERVs, check for a loose or broken belt or gear assembly and make sure that the wheel motor is operational. As needed, have an expert evaluate and/or repair the wheel rotor assembly.

### Check/Adjust ERV Settings

- See if the frost control settings or economizer settings are significantly different from expected in the previous table. If so, make adjustments and/or work with a qualified expert to make control changes.

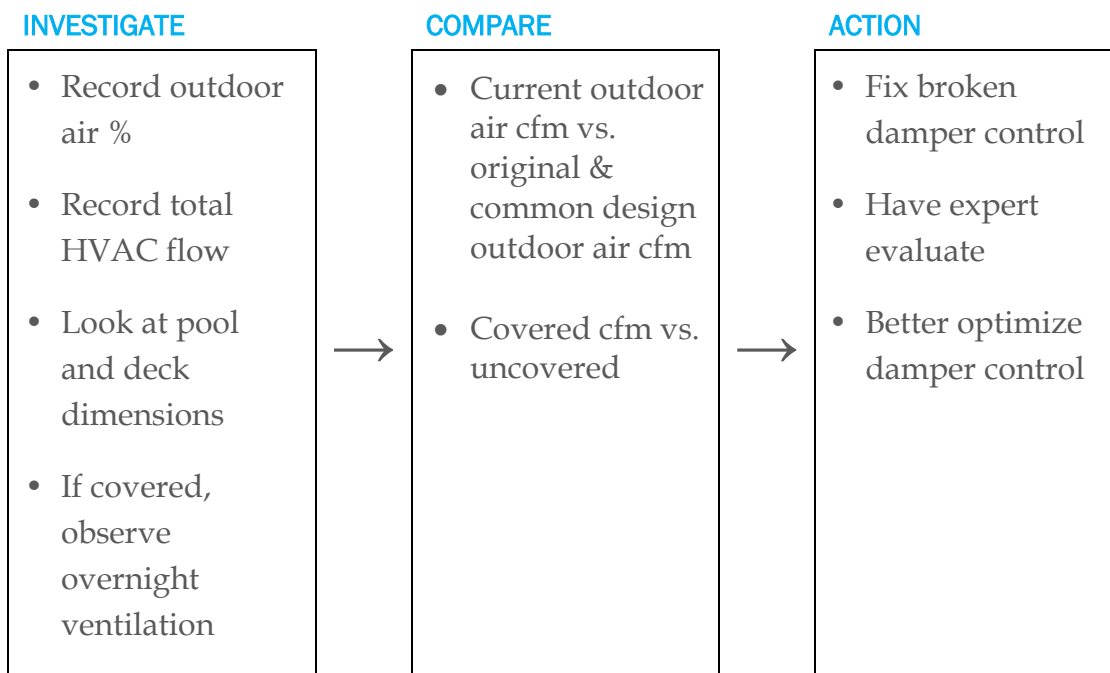
### Have the Control Evaluated By an Expert

- ERV controls often do not have the frost control and/or economizer control logic clearly shown on BAS system screens or other control diagrams, so it may be difficult to determine what the controls are trying to do.
- As necessary, consult an expert to evaluate and correct ERV controls that are causing significantly different operation (more than 10°F variance from outdoor temperature ranges) than what is outlined in the table.

## H3. Outdoor Air Ventilation Rough Check

Continuous outdoor air ventilation to a certain degree is required in pool rooms to prevent air quality problems. Having too much outdoor air ventilation can greatly increase energy use and cause comfort problems, while not providing enough outdoor air can contribute to air quality problems and condensations issues, as well as extra dehumidifier energy use and wear. Here is how you can check to see if this is an issue.

### WHEN TO CHECK: QUARTERLY (EXCEPT IN THE SUMMER)



### INVESTIGATE

#### Observe Current Minimum % Outdoor Air Damper % Open Outdoor Air Damper

- For systems connected to a BAS system, a careful look through the display screens may clearly show the minimum outdoor air damper setting and current intended damper position. A manual observation of the damper position should be carried out to confirm the actual current percent outdoor air.
- If the weather outside is cool, the system is likely already at the minimum outdoor air so there may be no need to do anything special to observe the minimum outdoor air control condition.
- If necessary, the dehumidifier control can typically be temporarily set to a humidity setpoint that is 15% to 20% RH above the current sensor reading. This should disable any dehumidification efforts by the HVAC unit and may cause it to operate at the minimum outdoor air. However, some economizer control features will make it difficult to force the unit to temporarily control to the minimum outdoor air, especially in mild weather.

- For systems with variable outdoor air dampers, observe outdoor and return air damper temperatures  
Outdoor\_Air \_\_\_\_\_% open; Return Air \_\_\_\_\_% open
- Note that some HVAC units are not designed to bring in 100% outdoor air even when the outdoor air opening is fully opened. If the outdoor air opening has a smaller area than the supply duct, record the dimensions of the outdoor air opening \_\_\_\_\_inches by \_\_\_\_\_inches; and supply duct \_\_\_\_\_inches by \_\_\_\_\_inches

#### Find Pool HVAC Unit Total Design Flow (cfm)

- The HVAC unit total supply flow may be shown on the equipment's nameplate, on plans (look at the mechanical schedules which are usually the last M pages), equipment documentation within a 3-ring binder, or on a BAS display screen.
- If it cannot be found by any of the above means, find the unit's manufacturer, model number, and serial number from the nameplate and contact the manufacturer to find out (start with a local manufacturer's representative if available).

#### Obtain Pool and Wetted Duck Dimensions \_\_\_\_\_ft by \_\_\_\_\_ft

- Do not include spectator areas, which are generally meant for people that are not swimming; only measure the area of the pool and around the pool that is designed for swimmers to occupy.

#### If Pool Cover is Used, Investigate Outdoor Air Control during the Covered Pool Time

- If there is BAS control of the HVAC unit, there may be an indication in the BAS screens or documentation about the intent to control outside air differently when the pool is covered. If so, it is still recommended that you actually observe that the system follows this intent at a time when the cover is in place and the ventilation is to be reduced.

### COMPARE

#### Current Minimum Outdoor Air Ventilation Rate

- If the outdoor air opening is smaller than the supply duct, calculate the ratio of opening sizes:

$$\frac{\text{outdoor air duct area (____inches} \times \text{____inches)}}{\text{supply air duct area (____inches} \times \text{____inches)}} = \text{____\% max outdoor air (OA)}$$

- Calculate current outdoor air flow:

$$\text{Total flow ____cfm} \times \text{OA damper ____\% open} \times \text{max outdoor air ____\%} = \text{____cfm Actual OA}$$

#### Common Design Outdoor Air Ventilation Rate

- Calculate the wetted pool area as the product of the pool area dimensions: square feet.
- Calculate a current typical outdoor air design flow (not considering spectator area):  
 $\text{Wetted pool room area ____ square feet} \times \text{0.5 cfm per square foot} = \text{Typical ____ OA cfm.}$
- If the actual outdoor air cfm and typical outdoor air cfm are more than 20% different, the take action to have an expert determine if a change is warranted.

### Other Indicators of Possible Outdoor Air Amount Issues

- An inability to keep adequate pool area temperatures, or low discharge air temperatures, could be symptoms of the system providing too much outdoor air.
- Also, if *Outdoor Air % Open + Return Air % Open  $\neq$  100% ( $\pm 20\%$ )*, take action to save energy and reduce control problems.
- Indicators of potential over- and under-ventilation are also noted in the S1 check.

### Compare Pool Covered Ventilation to regular Occupied Ventilation

- If the outdoor air ventilation rate is not reduced significantly during most of the time that the pool is covered, take action to take advantage of this opportunity.

### ACTION

#### If Referred to Action Because of Improper Combination of Outdoor Air and return Damper Positions

- Inspect any linkages between dampers to look for loose connections. If simple tightening of a linkage doesn't provide a solution, have a qualified technician check the damper actuators and controls to identify and solve the problem.

#### If Mismatch between Actual and Typical Design Outdoor Air cfm, Consult an Expert and Possible Adjust Outdoor Air Damper Control

- Providing adequate outdoor air ventilation is critical so a qualified expert should be consulted to confirm the potential to change the minimum outdoor air flow, if this was suggested by the comparisons.
- The minimum outdoor air position is typically set via automatic modulating damper controls that receive a signal from a central BAS system or controls that are at the HVAC units. Where a comparison has found improper outdoor air flow control, modify the setpoints and/or programming to correct the issue.
- Sometimes the outdoor air is manually controlled or fixed with an opening that only has a manual balancing damper or no damper. If adjustable, this damper can be adjusted to obtain the proper outdoor airflow.
- Where sizable spectator areas are present, this can cause a need for higher ventilation rates during the events when a large number of spectators are present. A means to automatically or manually provide adequate outdoor airflow during these infrequent events should be provided. However, the needs during these infrequent events should not cause the pool area to receive more outdoor air ventilation than is needed during the rest of the year.

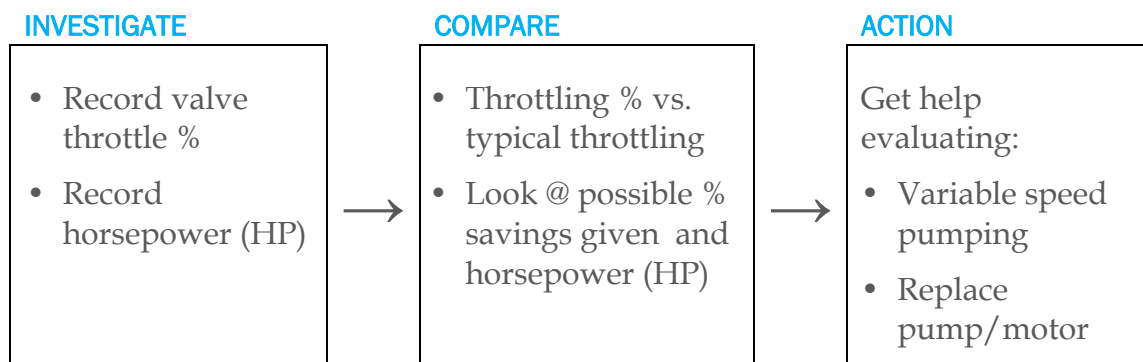
#### If Referred to Action for Not Reducing Ventilation When the Pool is Covered

- Explore options for reducing the outdoor air ventilation rate when the pool is covered.
- Ideally, a reduced, pool-covered, ventilation rate would be enabled and disabled by a reliable form of feedback about whether or not the cover is being used. An interlock with the pool cover mechanism is ideal.

## W1. Main Valve Throttling

Many public pools end up with pumps larger than what is actually needed because of safety factors in design and the limited selection of pump and motor sizes. For example, going from a 1 HP motor to a 1.5 HP motor (the next largest size) is a 50% jump in capacity. When dramatic oversizing occurs, the pool water flow rate is usually still limited to the minimum needed for adequate turnover by severely choking down the flow with a throttling valve. In such cases, the pump must work against a high pressure caused by the throttling and it uses much more energy than is really needed. Here's how to see if your system has severe throttling that may be worth correcting through pump motor control and/or replacement.

### WHEN TO CHECK: ANNUALLY



### INVESTIGATE

#### Locating Main Line Valves

- Although main line valves that may be throttled are typically located near the outlet of the pump, they could be anywhere along the main piping line that comes the pool to the pump, from the pump to the filter, and from the filter to the pool.
- Ignore throttling of valves along the main line that are used to force some water through smaller bypass lines (smaller pipes located just before and after the valve) that divert some of the main flow to the heater. (See [Valve Throttling Reference](#) for more detail.)
- Ignore any throttling of valves in the piping of a booster pump.

Record % Throttled for Each Valve: # 1 \_\_\_\_\_%; #2/Spa \_\_\_\_\_%; #3 \_\_\_\_\_%; #4 \_\_\_\_\_%

- Note the percentage closed above for each main line valve based on where the valve handle points between perpendicular to the pipe (100%) and parallel to the pipe (0%).
- See "[Valve Throttling Reference](#)" for more detail on valve position.

#### Record Pump Horsepower (HP)

- Record pump nameplate HP (look on the pump or motor nameplate) for the pump corresponding to each valve noted above Valve # 1 \_\_\_\_\_HP; Valve #2 \_\_\_\_\_HP; Valve; #3 \_\_\_\_\_HP; Valve #4 \_\_\_\_\_HP

## COMPARE

- If any main line valve is throttled 25% or more, use the table in “Valve Throttling Reference” to estimate potential annual kilowatt-hour (kWh) savings using the percent throttling value in combination with pump horsepower.
- Also use the table if a pump larger than 5 HP has a valve throttled 10% or more.
- Estimate potential cost savings by multiplying the kWh savings by \$0.11 per kWh (or another available representative utility rate that includes usage and demand savings).
- If the potential energy savings is significant enough, take action to save energy.

## ACTION

- Consider the installation of a variable speed pump or the addition of a variable speed drive to the pump motor. Operating at a lower pump speed with the previously throttled valve wide open can provide the required flow while using less energy.<sup>2</sup>
- If the economics of the variable speed drive retrofit based on the above estimate is questionable, have an engineer or other qualified individual perform a detailed analysis of the potential to replace the pump and/or motor with one selected to provide the design flow without significant throttling.

### Example of a Variable Speed Drive for a Pump



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<sup>2</sup> More information about variable speed pool pump control can be found in NSPF, Ch.10 and NRPA, 7-6 to 7-7.

## Reference for H1: Compressor Observation Tips

This section of the guide gives tips for manual observation of whether or not a dehumidifier compressor is operating. The first two approaches will only provide a spot check to see if a compressor is running at the exact time of the observation (or shortly before with refrigerant line temperature observations) and if it can be repeated periodically over the course of a few hours to see if a compressor is cycle. The last item describes how a variation of the refrigerant line temperature check can be used to see if a compressor cycles on at all over a period of time.

### LISTENING

When close to a unit, especially with the access panel open, the compressor sound alone is often enough to be able to tell whether or not it is running.

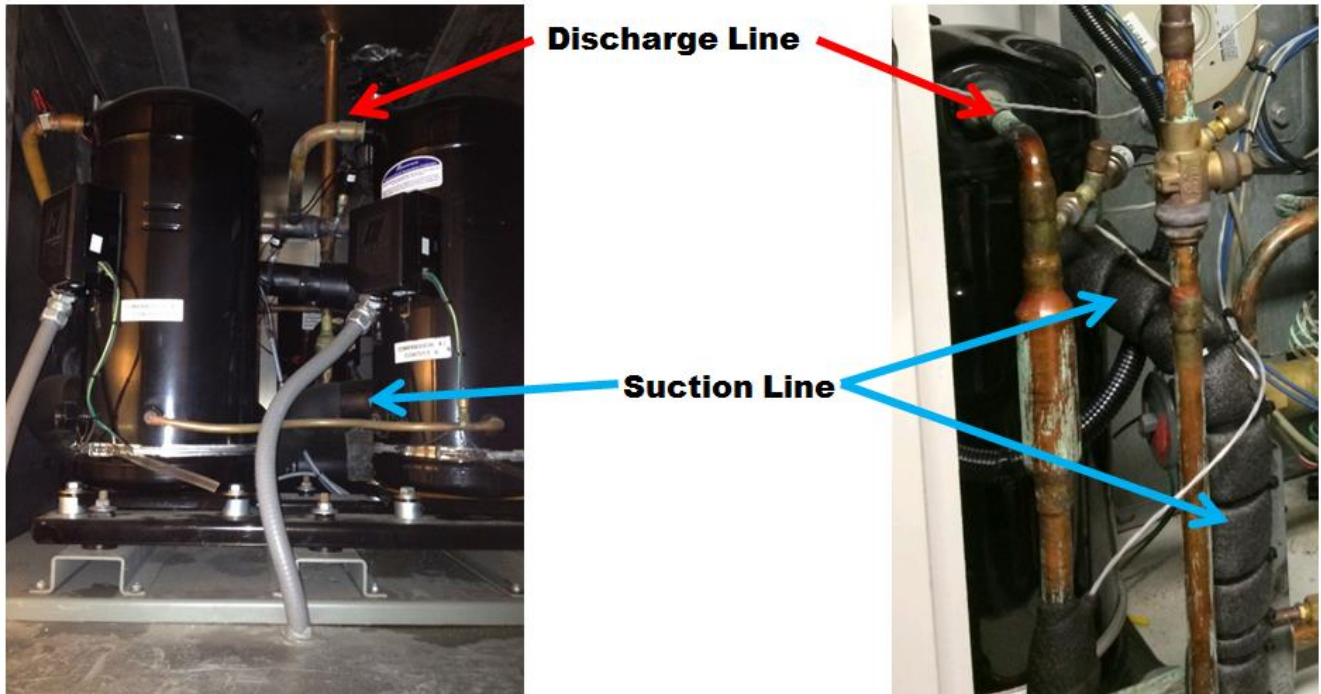
### CHECKING TEMPERATURE OF REFRIGERANT LINES

When sound alone isn't enough to determining whether or not a compressor is running, a rough temperature check of the suction (inlet) line and/or discharge (outlet) line will usually give a clear indication. These can be checked anywhere between the compressor and the other end of each line. See the table below and the figure on the following page for further direction.

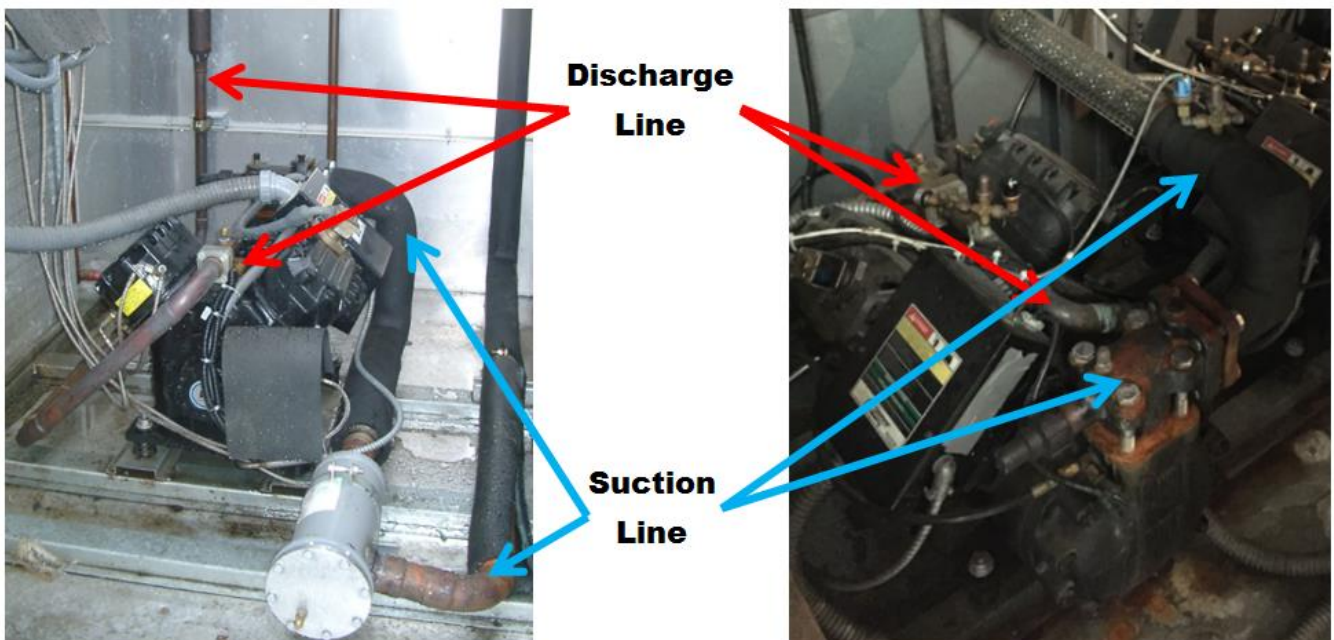
#### Suction and Discharge Line Identification and Observation

SUCTION (INLET) LINE	DISCHARGE (OUTLET) LINE
<b>How to Identify</b> <ul style="list-style-type: none"> <li>• Generally goes in horizontally.</li> <li>• Tends to be below discharge and into side (away from cylinders if reciprocating).</li> <li>• Often insulated.</li> <li>• Often larger than discharge.</li> </ul>	<b>How to Identify</b> <ul style="list-style-type: none"> <li>• May go out vertically or sideways.</li> <li>• Tends to be at the top of compressor (by cylinders if reciprocating).</li> <li>• Not insulated.</li> <li>• Often smaller than suction.</li> </ul>
<b>When Compressor Runs</b> <ul style="list-style-type: none"> <li>• Will feel cool or cold — can safely feel this near the compressor.</li> <li>• Is likely to have moisture condensation (sweat) on it, or even frost.</li> </ul>	<b>When Compressor Runs</b> <ul style="list-style-type: none"> <li>• Will be very warm or hot — This could be hot enough to burn, so do not touch without first holding your hand very near it for a few seconds and/or giving it a couple of split-second taps to be sure it is safe.</li> </ul>

### Examples of Scroll Compressor



### Examples of Reciprocating Compressor



### CHECKING FOR INTERMITTENT CYCLING

Besides instantaneous checks on the refrigerant line temperatures, there are temperature monitoring stickers that can be used to see if a given temperature has been reached over a period of time (or if the temperature has dropped below a certain value at some time). A dot or square darkens when the rated temperature of the sticker is exceeded.

If a spot check shows a compressor is not operating, but you would like to see if it cycles over a period of hours (or even days), put a sticker that activates when the temperature rises above a value of ~100°F to 115°F on the discharge line. After an hour or more, take a quick look back at the sticker to see if the compressor ran for at least some time between the time the sticker was put on and the time you looked at it.



## Reference for W1: Valve Throttling

This document gives tips for the observation of main valve throttling, as well as rough estimation of the energy cost savings possible through pump motor speed control and/or replacement with a properly sized pump.

### IDENTIFYING BYPASS LINES VERSUS MAIN THROTTLING VALVES

Many pool systems will have throttling valves that are used to force some water through a bypass line that goes through a heater or heat exchanger. This situation is not to be considered main valve throttling. The figure below shows an example of a heater bypass line that is supposed to have the valve in the main pool pipe throttled. The blue handled valve is partially throttled as it should be. Also note that the two copper ball valves are both in a wide open position as they should be. This situation below does not present a pump energy savings opportunity; you should be looking for valves in the main line located where all of the water flow goes through the valve during normal operation.<sup>3</sup>

#### Example of Bypass Line that is NOT Main Valve Throttling



### DETERMINING VALVE PERCENT CHOKED DOWN (AKA THROTTLED)

Pool systems generally have ball or butterfly valves, which makes it relatively easy to determine the valve position. With ball and butterfly valves, the handle(s) line up with the pipe when they are open all the way and the handle(s) are perpendicular to the pipe when they are closed all the way. The figures below show this clearly.

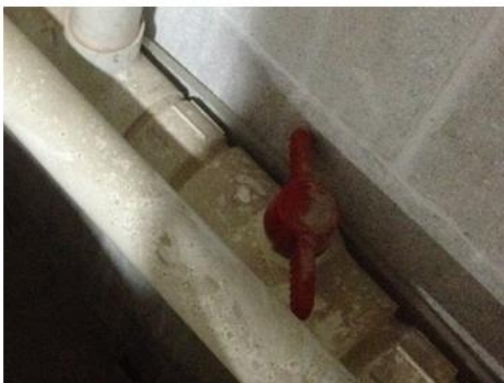
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<sup>3</sup> For more information about heater bypass valves and optimal adjustment see the National Recreation and Park Association (page 10-2).

Example of Valve Open (0% Throttled) – Ball Valve on Left, Butterfly Valve on the Right



Examples of Valve 35% Throttled – Ball Valve on Left, Butterfly Valve on the Right



ESTIMATED SAVINGS POTENTIAL

The following table can be used to estimate the electric energy savings potential for a range of combinations of valve horsepower and throttling percentage. Once the kWh electric use savings is determined, the annual energy cost savings potential can be estimated by applying an effective utility cost per kWh rate factor. If utility rate information is not readily available, a

good first approximation of the effective electric utility rate in Minnesota for 2017 is 11 cents per kWh.

#### Savings Potential for Correcting Valve Throttling

Pump HP	10% Throttled	20% Throttled	30% Throttled	40% Throttled	50% Throttled	60% Throttled	70% Throttled	80% Throttled
0.5	290 kWh	581 kWh	871 kWh	1,161 kWh	1,452 kWh	1,742 kWh	2,032 kWh	2,323 kWh
0.75	373 kWh	747 kWh	1,120 kWh	1,493 kWh	1,866 kWh	2,240 kWh	2,613 kWh	2,986 kWh
1	435 kWh	871 kWh	1,306 kWh	1,742 kWh	2,177 kWh	2,613 kWh	3,048 kWh	3,484 kWh
1.5	622 kWh	1,244 kWh	1,866 kWh	2,489 kWh	3,111 kWh	3,733 kWh	4,355 kWh	4,977 kWh
2	815 kWh	1,630 kWh	2,445 kWh	3,260 kWh	4,075 kWh	4,890 kWh	5,705 kWh	6,520 kWh
3	1,208 kWh	2,417 kWh	3,625 kWh	4,833 kWh	6,041 kWh	7,250 kWh	8,458 kWh	9,666 kWh
5	1,991 kWh	3,982 kWh	5,972 kWh	7,963 kWh	9,954 kWh	11,945 kWh	13,936 kWh	15,926 kWh
7.5	2,952 kWh	5,905 kWh	8,857 kWh	11,810 kWh	14,762 kWh	17,715 kWh	20,667 kWh	23,620 kWh
10	3,862 kWh	7,725 kWh	11,587 kWh	15,450 kWh	19,312 kWh	23,175 kWh	27,037 kWh	30,899 kWh
15	5,794 kWh	11,587 kWh	17,381 kWh	23,175 kWh	28,968 kWh	34,762 kWh	40,555 kWh	46,349 kWh
20	7,657 kWh	15,314 kWh	22,971 kWh	30,628 kWh	38,285 kWh	45,942 kWh	53,599 kWh	61,256 kWh
25	9,498 kWh	18,996 kWh	28,494 kWh	37,992 kWh	47,491 kWh	56,989 kWh	66,487 kWh	75,985 kWh
30	11,311 kWh	22,623 kWh	33,934 kWh	45,246 kWh	56,557 kWh	67,868 kWh	79,180 kWh	90,491 kWh
40	14,985 kWh	29,969 kWh	44,954 kWh	59,938 kWh	74,923 kWh	89,907 kWh	104,892 kWh	119,876 kWh