Checklist to Evaluate Economizers for Potential Operating Problems

Instructions: Evaluate your system for each of the items listed below to determine its susceptibility to economizer related operating problems. Include the recommended measures based on the results of the evaluation in the testing program for the system. Consult the appropriate section of *Chapter 9 Economizer and Mixing Section* for additional information on any of the topics. If you are using this in the electronic version, the hyperlinks will take you to the related section of the Guide, assuming it is available on your computer. When you click on the link, it will open the chapter in a separate window and put you at a location in the document that contains the related information associated with the hyperlink. You will also notice that the task bar at the bottom of your screen has buttons for both of the documents (as well as any other Word documents that you might have open). To return to this checklist, simply click on the button associated with it in the task bar at the bottom of your screen or in the Windows drop down menu.

Date(s) of Evaluation:____

Evaluator: ____

Item Number	Requirement	Initial and Date when Complete
Dampers, Actuators, and Linkage Systems		
1	**Is there an independent minimum outdoor air damper?** **Yes -** This is generally the best situation because it will allow the minimum outdoor airflow rate to be set and regulated independently from the economizer related maximum outdoor air function. ***Follow-up and Recommendations:*** Include functional testing in the Commissioning plan targeted at ensuring that the minimum outdoor air damper is set up properly to achieve the design intent for the system. **No -** Lack of an independent minimum outdoor air damper can lead to economizer related operating problems. The two most likely issues are: • The minimum flow is much higher than required because of the non-linear relationship between flow and damper stroke causing excessive energy consumption. • Low or no minimum outdoor airflow into the building causes indoor air quality problems (IAQ) and/or problems with pressure relationships. ***Follow-up and Recommendations:*** *Design Phase* - Recommend that the design team address the issue by providing a regulated, independent minimum outdoor air damper. Include functional testing in the Commissioning plan targeted at ensuring that the proper minimum outdoor air flow rate is set and maintained for the system. *Construction Phase* - Recommend that the outdoor air damper section be modified to provide a regulated, independent minimum outdoor air damper. *Retrocommissioning* - Consider modifying the existing minimum outdoor air damper assembly to provide an independent minimum outdoor air damper. Where this is not practical or possible, add a minimum outdoor air flow limit to the economizer control signal. Functionally test to ensure that the required minimum outdoor air flow is delivered.	
2	**Check damper sizing**. There are several approaches possible.	

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	Check based on size relative to the duct or louver they are associated with. If the dampers are the same size as the duct, plenum or intake louver they area associated with, then they probably are oversized. *Check based on nominal face velocity.* Proceed as follows. *Document the system design flow rate.* Unit rated capacity ______________ cfm *Document the maximum outdoor air damper size and calculate the area.* Height ______________ ft. Width ______________ ft. Area = Height x Width ______________ sq.ft. *Note the damper blade type (check the appropriate item)* Flat plate __________ Airfoil __________ *Calculate the nominal damper face velocity* Face velocity = Flow rate ÷ Area ______________ fpm For airfoil dampers in typical systems, velocities through the damper section in the range of 2,000 - 3,000 fpm are typically required to generate a pressure drop that provides a satisfactory alpha ratio and reasonable control. For flat plate dampers, the range is more like 1,500 - 2,000 fpm. **Based on the preceding rules of thumb, do the dampers appear to be sized properly?** **Yes -** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - Include documentation of damper sizing in project control submittal requirements. *Construction phase or Retrocommissioning* - Investigate further if subsequent functional testing indicates problems that can be related to damper sizing issues. **No -** Improper sizing can lead to a variety of operational problems including poor mixing and non-linear performance. In turn, these issues can lead to energy waste, nuisance freezestat trips, and premature component failure. ***Follow-up and Recommendations:*** *Design phase* - Request that the design team address damper sizing and related issues either directly or by including specific delegation of the responsibility to the control contractor. Require documentation of damper sizing in the project control submittals. *Construction phase* - Request that the control contractor document damper sizing and/or modify the damper sections as required to achieve the necessary level of mixing and linearity. Coordinate with the project designer to obtain an understanding of their design intent in this regard. Include functional testing designed to identify damper sizing issues early on such as the temperature traverse test and the flow linearity test. *Retrocommissioning* - Do further calculations to investigate the damper sizing requirements. Perform functional testing designed to identify	

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	damper sizing issues such as the temperature traverse test and the flow linearity test. Modify damper sections as necessary to achieve the desired level of performance.	
3	**A. Are the return and maximum outdoor air damper sections similar in size and arrangement?** **B. Are the dampers oriented in a manner that will promote mixing?** **C. Are the blades rotations set up in a manner that will promote mixing?** **Yes to all three items -** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - Include shop drawing requirements for installation details for all dampers as a part of the control system submittal. *Construction phase or Retrocommissioning* - Investigate further if subsequent functional testing indicates problems that can be related to damper configuration issues. **No to any one item -** Improper configuration can lead to a variety of operational problems poor mixing. In turn, these issues can lead to energy waste and nuisance freezestat trips. ***Follow-up and Recommendations:*** *Design phase* - Recommend that the design team include details on the contract documents describing the arrangement of all mixing dampers including blade orientation and rotation, damper arrangements, and blank-off plate locations and requirements or specifically delegate this responsibility to the control contractor via the specifications. Include shop drawing requirements for installation details for all dampers as a part of the control system submittal. *Construction phase* - If the dampers are already installed, then, other than for blade rotation, it is usually best to wait to modify or reconfigure the damper sections based on the results of functional testing. If blade rotation is an issue, recommend that the dampers be reoriented so that the blade rotation promotes mixing. This is easier (less costly) if you can catch the problem before the actuators are installed and piped. Perform functional testing designed to identify damper configuration issues such as the temperature traverse test and the flow linearity test. Modify damper sections or install baffling as necessary to achieve the desired level of performance. *Retrocommissioning* - Reorient the dampers to correct any blade rotation problems. Perform functional testing designed to identify damper configuration issues such as the temperature traverse test and the flow linearity test. Modify damper sections or install baffling as necessary to achieve the desired level of performance.	
System Turn Down (Variable Flow Systems Only)		

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1	**If the system is required to operate at different flow rates, either because it is a VAV system or a system equipped with a multi-speed motor, then evaluate its turn down ratio using one of the following three techniques.** *Method 1* - Turn down ratio for systems with several different operating flow rates. A = Rated flow at maximum speed _________ cfm B = Lowest rated flow _________ cfm Turn down ratio = A ÷ B _________ *Method 2* - Turn down ratio for VAV systems with a terminal unit schedule stating maximum and minimum flows and no zone level scheduling.[1] A = Maximum rated flow = AHU's rated cfm _________ cfm B = Minimum flow = Sum of minimum flow rates for all units served by the AHU _________ cfm Turn down ratio = A ÷ B _________ *Method 3* - Turn down ratio for VAV systems with a terminal unit schedule stating maximum and minimum flows and with zone level scheduling. A = Maximum rated flow = AHU's rated cfm _________ cfm B = Minimum flow = Sum of minimum flows for the smallest group of terminal units that can run in an occupied mode with all of the others in an unoccupied mode. _________ cfm Turn down ratio = A ÷ B _________ **Is the turn down ratio greater than 2:1?** **No -** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - None *Construction phase or Retrocommissioning* - Investigate further if subsequent functional testing or trending indicates operating problems that can be related to performance at low percentages of design flow. **Yes -** Variable flow systems with high turn down ratios may have difficulty operating at low percentages of design flow (high turn down ratio), especially if the dampers are marginally sized at design flow. ***Follow-up and Recommendations:***	

[1] Zone level scheduling is a technique that uses a schedule to control the terminal equipment on a VAV system. If the area served by the terminal equipment is unoccupied, then the terminal unit damper is driven closed. The central system then backs down due to the normal fan volume control system responding to this reduction in flow. The central system is shut down when none of the zones it serves are in the occupied mode. Night set back and set up routines return the terminal equipment to the occupied cycle on a temporary basis if necessary to hold unoccupied space temperatures within some temperature range.

In system level scheduling, the central system is shut down if all of the zones it serves are unoccupied, but unoccupied zones continue to operate based on their current set points and never reduce their flow below the terminal unit minimum flow settings. The technique has the advantage of saving energy by eliminating the minimum flow associated with unoccupied zones. But, it generally means the system will have a higher turn down ratio since in theory, it may have to run to serve only one terminal unit operating at its minimum flow. Usually, this is impractical so the controlling software is arranged to schedule terminal units in blocks with the smallest block size being determined by the turn down capability of the system.

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	Design phase - Investigate alternatives that allow the system to perform better at low flow rates. *Construction phase* - Include functional tests such as the High Turn Down Test in the commissioning plan to verify system performance at low percentages of design flow. *Retrocommissioning* - Perform functional tests such as the High Turn Down Test to identify either the limiting flow condition where damper performance has degraded to the point where the economizer function is no longer reliable or confirm economizer reliability at the lowest flow rate routinely seen by the system. Coordinate with the operating staff to identify operating options or control modifications that will provide reliable system performance at the required operating conditions.	
Mixing conditions		
1	**Is there sufficient distance between the mixing plenum and the freezestat and/or first coil with a potential for freezing to allow mixing to occur?** **Yes-** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - None *Construction phase* - Monitor construction to verify that the spacing incorporated in the design is maintained in the actual installation. Consider including a test procedure such as the Temperature Traverse Test in the functional testing plan to document and verify the mixing performance. *Retrocommissioning* - Consider including a test procedure such as the Temperature Traverse Test in the functional testing plan to document and verify the performance. **No -** Insufficient distance for mixing to occur can cause operating difficulties with the economizer system that can prevent it from achieving its design intent. ***Follow-up and Recommendations:*** *Design phase* - Investigate alternatives that allow the system to provide better mixing conditions. Air blenders are one option if sufficient distance can not be provided. *Construction phase* - Monitor construction to verify that the spacing or other mixing features incorporated in the design is implemented in the actual installation. Consider including test procedures such as the Temperature Traverse Test in the functional testing plan to document and verify the performance. *Retrocommissioning* - Perform a test procedure such as the Temperature Traverse Test to identify the magnitude of the problem. Based on the test results, evaluate retrofit options that could help address any issues identified.	
Sensors and Control		

Item Number	Requirement	Initial and Date when Complete
1	**Have the temperature sensing elements associated with the economizer function (Typically, the mixed air sensor and freezestat) been located and arranged in a manner that ensures they will reflect the true conditions in the mixed air plenum?** **Yes-** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - None *Construction phase* - Monitor construction to verify that the requirements of the design are reflected in the actual installation. *Retrocommissioning* - Consider including a test procedure such as a Temperature Traverse Test in the functional testing plan to document and verify that the sensing elements reflect the true mixed air plenum conditions. **No -** Poorly located and arranged sensing elements can cause numerous problems with the operation of the economizer cycle and related safety functions. ***Follow-up and Recommendations:*** *Design phase* - Request that the designers provide guidance on the contract documents regarding requirements for the installation and location of the sensing elements. *Construction phase* - Monitor construction to verify that the sensor installation reflects the requirements of the design. Consider including test procedures such as a Temperature Traverse Test in the functional testing plan to document and verify the performance. *Retrocommissioning* - Perform a test procedure such as a Temperature Traverse Test to identify the magnitude of the problem. Based on the test results, modify the sensor installation as required to achieve satisfactory performance.	
2	**A. Does the design include appropriate controls and interlocks to enable and disable the economizer function as appropriate for the ambient conditions, system operating conditions, and safety requirements?** **B. Are the set points for these interlocks clearly defined on the documents and appropriate for the project local?** **Yes to all -** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - None *Construction phase or Retrocommissioning* - Include functional tests like the Ambient Interlock Test to verify proper functionality. **No to any one item -** Improperly set or missing interlocks can lead to operational problems and energy waste. ***Follow-up and Recommendations:*** *Design phase* - Request that the designers provide guidance on the contract documents regarding interlock requirements and settings. *Construction phase* - Include functional tests like the Ambient Interlock Test to verify proper functionality.	

Item Number	Requirement	Initial and Date when Complete
	Retrocommissioning - Evaluate the existing system to determine interlock requirements and appropriate settings. Implement any necessary changes and perform a functional test like the Ambient Interlock Test to verify proper functionality.	
3	**If the system does not have an independent mixed air controller or control loop, is it provided with a mixed air low limit control loop?** **Yes -** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - None *Construction phase or Retrocommissioning* - Include functional tests like the Mixed Air Low Limit Test to verify proper functionality. **No -** Systems with economizers that are controlled by a condition downstream of the mixed air plenum can be difficult to start in subfreezing winter weather. ***Follow-up and Recommendations:*** *Design phase* - Request that the designer's include a mixed air low limit sequence in the control requirements for the project. *Construction phase and Retrocommissioning* - Include functional tests like the Mixed Air Low Limit Test to verify proper functionality.	
4	**Does the control sequence and design of the air handling system adequately address the building pressure control requirements generated by operating on an economizer cycle?** **Yes -** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - None *Construction phase or Retrocommissioning* - Include functional tests like the targeted at verifying the integrated performance of the building pressure control system with the economizer system as necessary to meet the design intent for the project. **No –** The extra air brought in by an economizer cycle that slightly pressurizes a building can provide significant benefits in terms of energy conservation and comfort. Failing to address building pressure control requirements can cause significant operating problems. ***Follow-up and Recommendations:*** *Design phase* - Request that the designer's include a building pressure control sequence in the control requirements for the project. *Construction phase* - Include functional tests like the targeted at verifying the integrated performance of the building pressure control system with the economizer system as necessary to meet the design intent for the project. *Retrocommissioning* - Include functional tests targeted at identifying the impact of the economizer cycle on building pressure with the economizer system in various operating modes. On high-rises, large buildings or buildings that are part of an interconnected complex, consider performing the Building Pressurization Test to evaluate the pressurization needs of the building and the impact the economizer cycle can have on addressing it.	
5	**Has the control of the economizer dampers been fully integrated with the**	

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	control of the other heat transfer elements in the system? **Yes -** No additional effort is required at this time. ***Follow-up and Recommendations:*** *Design phase* - Request that the design team include appropriate alarms and smart alarms to annunciate problems with the economizer system and its integrated performance with the other air handling system control functions. *Construction phase or Retrocommissioning* - Include functional tests like the targeted at verifying the integrated performance of the economizer system with the other heat transfer elements in the air handling system as necessary to meet the design intent for the project. **No -** Failure to fully integrate the economizer function with the operation of the other heat transfer elements in the air handling system can result in energy waste that is difficult to address directly. ***Follow-up and Recommendations:*** *Design phase* - Request that the designer include a building pressure control sequence in the control requirements for the project. *Construction phase* - Include functional tests like the targeted at verifying the integrated performance of the building pressure control system with the economizer system as necessary to meet the design intent for the project. *Retrocommissioning* - Include functional tests like the targeted at identifying the impact of the economizer cycle on building pressure with the economizer system in various operating modes. On high-rises, large buildings or buildings that are part of an interconnected complex, consider performing the Building Pressurization Test to evaluate the pressurization needs of the building and the impact the economizer cycle can have on addressing it.	

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