Solving the Apparent Mystery of Economisers

It would appear from the number of sites that we have visited in recent times that there is a lack of understanding about economisers and how the economiser cycle is supposed to work. This is surprising to us but nevertheless perhaps we should address this. We have recently seen numerous units with the fresh air dampers wide open in the heating cycle, the compressors running and the outdoor coils a solid block of ice and the serviceman scratching his head.

Before we continue ask yourself this simple question.

The air in the space is 22.0°C 50%RH and the outside ambient condition is 20°C 65%RH.
Which contains the most heat? Think about it. The answer is in the body of this article.

Principles of Economiser Operation

The basic principle is the ability to **utilise available free cooling** from the outside air **in the cooling cycle** when it is lower in heat content than the current mix of the return and limited fresh air introduction. The return air damper is closed off and the fresh air damper moved from its slightly open position (supplying a limited amount of fresh air to suit the building/personnel demand) to a position to allow full fresh air entry.

The same philosophy could also apply in heating mode should the temperature or heat content of the outside air be greater than the return/fresh air mix. This is never the case and therefore this is not an option.

The economiser cycle is set up as the **first stage of cooling** with compressors being called to operate as the second and third stages etc. Now herein lys the first issue. Unless an air conditioning unit has been designed specifically to operate on the cooling cycle with the fresh air damper fully open and the compressors operating, then **the economiser fresh air damper must be returned to its original limited position and the return air damper fully opened before any compressors are allowed to run**.

If the compressors were to be allowed to run with the economiser open then there is a very strong possibility of the indoor coil icing up!!

Economiser Control

This is where it gets very interesting…….

We **strongly recommend economiser control is achieved by measurement of the enthalpy** (heat content) or by the wet bulb temperature, not by dry bulb temperature, **of the outside air**. **Control by dry bulb temperature alone can result in adding substantial load to the building** in the form of latent load. It is most important that the total heat content of the air is lower than the space/return air not just the dry bulb temperature.

We have some other recommendations that will help in gaining good control and minimise energy wastage.

1. We recommend that when the system is turned off, such as overnight, that the fresh air damper is returned to a fully closed position to prevent cold air dumping in to the space, this has been seen to occur on several sites.
2. In heating cycle either have a warm up cycle where the fresh air damper is not allowed to open at all until the room condition has been achieved for the first time after start up, or alternatively have night set back where the system does not stop but is set to control at a lower (winter) or higher (summer) space temperature such that the system has a head start and less energy is required to return the space temperature to its design set point. In many cases night set back uses little more energy than switching off and having to induce a huge amount of energy to get back up to the desired temperature at peak power rates. Refer also *Application Notice 06/02* on this subject.
3. If a CO2 or air quality sensor is fitted then this should be a modulating device so that the affect on the system is minimal. An on/off device that opens the fresh air damper fully in short bursts can have a devastating effect on the system performance.

Limiting the Fresh Air Damper Opening

When the system is operating with full or predominantly return air there is a system balance that (hopefully) has the right air flow at the right development of static resistance. When the economiser mode comes in to play, as soon as the return air damper starts to close and the fresh air damper open, air will always take the least line of resistance and inevitably with less overall negative static resistance the overall air flow will increase.

This results in an increase in the air velocity over the coil and bearing in mind that fresh air often has far more moisture content than the return air it can often lead to issues with water carry over.

In an ideal world the fresh air damper should only open a small amount so that the resistance through it is equal to the system resistance that existed in the return air mode. This is very rarely the case. For this reason we are making all OPA and PA units with epoxy finned indoor coils as epoxy fin has qualities to improve adhesion of the water to the coil fin surface and reduce the likelihood of water carryover.

This should not be relied on totally. If a system were to be controlled against our recommendations by temperature alone or should the compressors be allowed to run when the economiser fresh air damper is open then consideration should be given to keeping the design air flow down so that the coil air velocity is closer to 2.0 m/s. Full fresh air systems are/ should be limited in this same way.

Economiser in the Heating Cycle

We do not recommend the use of the economiser mode during the heating cycle; it is rare that there is more heat in the outside air than is available in the return air. However we have found a number of sites with the economiser fresh air damper fully open during heating mode and the compressors are in operation which naturally voids standard warranty.

Lack of Heat In De-Ice

If units are operated with the fresh air damper open in the heating mode (unless just cracked for the minimum fresh air introduction) and compressors are allowed to operate then in the colder ambient conditions three issues will come to the fore, any of which voids standard warranty.

1. The system will struggle to heat properly because with too low an air temperature on to the coil the system will not generate sufficient head pressure, and therefore differential pressure between the high side and low sides of the system, to make expansion devices feed properly.
2. The lower head pressure causes the evaporating pressure to fall also and in turn results in excessive ice build up on the outdoor coil that may not be removed by a standard de-ice cycle.
3. When the system goes in to de-ice there will be insufficient heat source to quickly de-ice the outdoor coils resulting in some ice remaining on the coils which has a snowball effect until the outdoor coils become a complete block of ice.

Topping Up Free Cooling with One Compressor

This is not recommended; as **if it is not done correctly it could easily void the warranty**. However within some limitations this can be a possible option and our *Application Notice 02/04* covers this in some detail. We recommend contacting temperzone Engineering staff for assistance.

Operation Outside of Design Conditions (especially on start-up)

Application Notice 04/07 covers this in some detail. This is not just applicable to units with economisers fitted but is of more concern when they are.

When units are first started up especially in winter operation they will be running outside of design conditions for long periods as the building fabric has to be brought to temperature and units may therefore need nursing through this period. One thing to be very cautious of is the air velocity across the indoor coil. This is not easy to absolutely define as it is so dependent on the air's moisture content and relative humidity.

Under **normal air conditioning conditions** (50% Relative Humidity and say between 21.0°C db and 25.0°C db) the velocity of the air across the indoor coil is best kept at or below **2.5 m/s**.

If the system can operate with **Full Fresh Air** then the velocity across the coil should be kept down around **2.0 m/s**. Fresh air can obviously contain extremely high amounts of moisture.

Should the application be **High Sensible Heat Ratio, i.e. 0.85 SHR and above**, in applications such as machine rooms or telephone exchanges etc. then the velocity can be allowed to drift up to **2.8 m/s** as there will be little moisture being condensed on the coil.

Likewise if the **Sensible Heat Ratio is 1.0** and no moisture is being condensed at all then a velocity as high as **3.0 m/s** is acceptable.

These figures can only be regarded as rule of thumb.

Control Limits

We recommend that if the unit is to operate outside of the design conditions shown in the published product technical literature that temperzone Engineering be consulted.

Typical standard design limitations would be: -

Summer/Cooling

Indoor on coil **21.0°C db 15.0°C wb** to **31.0°C db 21.0°C wb**

Outdoor Ambient **20.0°C db** to **43.0°C db**

Winter/Heating

Indoor on coil **15.0°C db** to **30.0°C db**

Outdoor Ambient **-5.0°C db** to **20.0°C db**

In Summary

1. **Use Enthalpy sensing to control the economiser cycle not temperature sensing.**
2. **Limit the amount the fresh air damper can open.**
3. **Keep an eye on the air flow and resulting velocity across the coil.**
4. **Use warm up cycles or night set back to give the unit a chance to work properly first thing in the morning before introducing any fresh air.**
5. **Don't use the economiser cycle in heating mode unless some real benefit can be proven.**
6. **Don't run compressors during the economiser cycle.**
7. **On initial start up especially in winter conditions units should be monitored closely as they may be operating outside of design conditions for long periods and compressors and coils could suffer catastrophic failure from ice up and/or liquid slugging.**

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