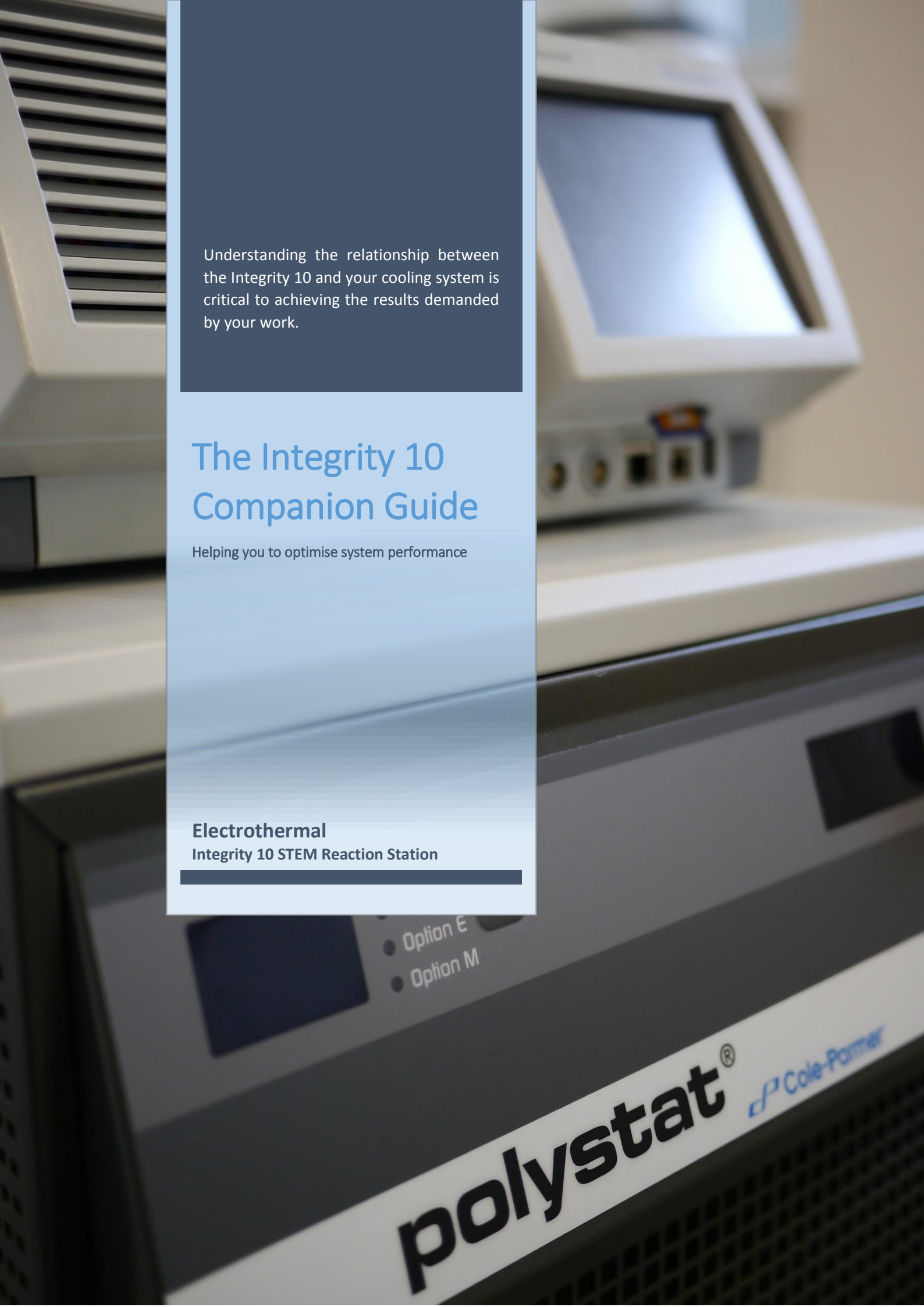

Understanding the relationship between the Integrity 10 and your cooling system is critical to achieving the results demanded by your work.

The Integrity 10 Companion Guide

Helping you to optimise system performance

Electrothermal

Integrity 10 STEM Reaction Station

⚠ The Integrity 10 reaction station must be used with an appropriately rated cooling system at all times, even when the equipment is only used for heating applications.

⚠ Failure to use an appropriately rated cooling system will negatively impact the performance of the Integrity 10. In some circumstances this could reduce the life of the product, increase service frequency or cause permanent damage.

⚠ Damage caused to the Integrity 10 through the use of inappropriately rated cooling systems is not covered under warranty.

⚠ Damage caused to the Integrity 10 through the use of unfiltered or contaminated coolant is not covered under warranty.

Integrity 10 Cooling Requirements

The Integrity 10 is capable of independently cooling each of its 10 cells down to a minimum temperature of -30°C, but this is only achievable when the product is coupled to a cooling system that can remove heat at a rate **greater or equal to** that collected by the Integrity.

It is important to understand the importance of this relationship and to select an appropriate cooling system so that you can achieve the performance needed for your application and get the results you expect.

Understanding the systems relationship

Each of the Integrity's cells contain a cooling device (the TEC). While operating in cooling mode, these devices remove heat from the reaction vessel and pass it onto the cooling system via a heat exchanger. The temperature of the coolant increases which is then pumped out of the Integrity, where it's cooled by the chiller and rejected into the air.

⚠ It is important to note that even when a cell is heating and not using the cooling feature, a cooling system is *still* required to ensure damage is not sustained to the sensitive cells during operation.

☺ When appropriately matched, the cooling system and Integrity work in harmony and are able to achieve the performance expected.

☹ If inappropriately matched, the cooling system is unable to keep up with the demands placed upon it. In this situation, the cooling performance of the Integrity is negatively impacted reducing the rate of cooling and/or limiting the minimum temperature the cell is able to achieve.

In extreme circumstances i.e. when a cooling system is severely under-rated, the chillers reservoir of coolant will progressively increase in temperature until the cooling system displays an error message and potentially stops operation.

Managing the load on the cooling system

Knowing how to manage the load placed upon your cooling system will help you achieve the performance you require and will also help you save energy.

There are three main factors which contribute to the load on the cooling system:

- The number of cells being cooled at any time.
- The cooling rate selected.
- The minimum temperature required.

Example 1
Cooling 10 cells in parallel places a higher load on the cooling system than only cooling 2 cells in parallel.

Example 2
Cooling at a rate of 5°C/minute places a higher load on the cooling system than cooling at 1°C/minute.

Example 3
Cooling down to a temperature of -30°C places a higher load on the cooling system than cooling down to a temperature of -10°C.

In a worst case scenario, an experiment would demand all 10 cells to cool to -30°C in parallel, using an uncontrolled ramping profile. Uncontrolled ramping is when a user hasn't specified a ramp-rate in the Integrity settings. In this situation, both the Integrity and cooler will need to work their hardest to reach the desired temperature.

The Integrity is easily capable of cooling all 10 cells down to a temperature of -30°C, provided it is coupled to an appropriately rated cooling system. The time taken to reach a temperature of -30°C using uncontrolled ramping is subjective and dependant on:

- The performance capabilities of the cooler.
- The ambient temperature in the laboratory.
- The contents of the vessel and its heat capacity (i.e. the amount of energy which must be removed from the contents in order to yield a measurable temperature change).
- The nature of the experiment being performed (e.g. exothermic reactions).

Reducing the load on the cooling system

If you believe your system is struggling to meet the performance demands placed upon it, consider the following list of suggestions to help reduce the load on the system:

- Increase the temperature of the experiment.
- Reduce the number of cells which are cooling in parallel.
- Ensure your cooling system is regularly serviced and is maintained in line with the manufacturer's recommendations.
- Ensure the coolers condenser is clean and has unrestricted air-flow.
- Ensure coolant is clean with no contaminates which can block the Integrity heat exchangers.
- Reduce the cooling ramp-rate of the experiment.
- Reduce the ambient temperature of the laboratory using air conditioning.

A good indication that your cooling system is under-rated for your experiment is when you observe a temperature plateau when working below ambient temperatures.

For example: You set up the Integrity to cool all 10 cells down to a temperature of -20°C however you noticed that the cells have only reached -15°C. The cooler is struggling to meet the demands placed upon it because the rate at which heat is gathered by the Integrity now matches the capability of the cooler. (You may also observe an undulation in the minimum temperature as the coolers compressor cycles on and off in an attempt to maintain the coolants temperature.)

Selecting a cooling system

Now that we've explained the relationship between the Integrity 10 and the cooling system, we shall discuss the important specifications of the cooling system.

There are four primary considerations when selecting a cooling system:

1 Working temperature range

The first parameter to consider when selecting your recirculating cooler is the working temperature range. In order for the Integrity to reach a minimum temperature of -30°C, the cooler will need to be capable of working between 5°C and -5°C.

The working temperature you use will be subjective to your experiment and is typically determined empirically. We recommend you start at 5°C and progressively reduce the coolers temperature until you achieve the performance required.

> Tip: Don't set your chiller cooler than needed - it is always best practice to use the warmest working temperature possible which achieves your performance requirements to avoid unnecessary condensation and to avoid wasting energy.

2 Cooling Capacity

The cooling capacity is a characteristic which determines how quickly the cooler can remove the heat collected by the Integrity. As mentioned previously, the cooler needs a capacity **greater or equal** than that of the Integrity, so that the performance of the whole system can be comfortably maintained.

It is recommended that you select a product with a cooling capacity of at least 1.1KW (1100W) between the working temperature of range of 5 to -5°C. With this cooling capacity, you will be able to use the Integrity 10 to its maximum potential.

Most manufacturers of recirculating coolers typically specify the cooling capacity of their equipment using a table, because there is a relationship between working temperature and cooling capacity of such systems.

For example, see the fictitious table below:

Working temperature (°C)	20	10	0	-10
Cooling Capacity (kW)	2.5	1.8	1	0.4

As you can see from this table, the cooling capacity decreases significantly as the working temperature is reduced.

It should be noted that manufacturers of recirculating coolers would advertise this system as a *nominal* 2.5kW system. This is in fact the cooling capacity at 20°C only. You should always determine the cooling capacity over the recommended working temperature range of the Integrity.

It's possible to run the Integrity using a lower rated cooling capacity, although this isn't recommended. Please see the next section on 'lower rated systems' for more information about this.

3 Flow Rate

The cooler should be capable of providing coolant at a rate of at least 5 Litres per minute, *directly* into the Integrity.

If you are sharing your cooling system with other equipment or accessories, you must ensure that the supply of 5 Litres per minute is maintained for the duration of your work.

Do not compromise the flow rate of the coolant into the Integrity by using incorrectly specified ancillary items such as couplers, reducers or tee-pieces, for example.

4 Pressure

In order to obtain the flow rate discussed above, the coolers pump must be capable of providing a pressure of at least 2 bar.

If you are sharing your cooling system with other equipment or accessories, you must ensure that the pressure of at least 2 bar is maintained for the duration of your work.

Lower rated systems

It is not recommended that you use the Integrity with a lower rated system than explained above. If you do, you will not necessarily be able to reach the performance characteristics required by your work nor will you be able to exploit the full potential of the Integrity 10 and cool all cells down to a minimum temperature of -30°C

Filtering requirements

When coupling your Integrity 10 to a cooling system it is required that you also fit a 50 micron inline filter (if one is not present in the cooler) to prevent the ingress of contaminates into the cell heat exchangers. The filter should be installed on the outlet of the chiller.

Partial restriction or blockage of heat exchangers caused by contaminates will impact the system performance and potentially void your warranty.

Summary of cooling system specification

Working temperature range	5 to -5°C
Cooling Capacity	1.1kW (1100W) between 5°C to -5°C
Flow Rate	≥ 5 Litres per minutes
Pressure	≥ 2 bar
Inline Filter	50 micron

Table 1 - Recommended specification of Integrity 10 cooling system

Circulating Fluids

Once you have selected your cooling system, you will need to follow the manufacturer's recommendation and use a fluid suitable for your application. Manufacturers will recommend avoiding anti-freeze intended for cars, instead prompting use of fluids designed specifically for lab equipment.

When working with refrigerated and other cooling equipment, it is important to use a fluid that will not freeze because the temperature inside the cooling equipment may be significantly colder than the set temperature.

Circulating Fluids – Cooling

Water-based synthetic fluids are popular choices for cooling. They can be used across a broad temperature range, especially when used in sealed or vacuum systems. Glycols, when mixed with water, become antifreeze. This does not mean that you can buy and use automotive antifreeze. What's good for your car is not necessarily good for your lab equipment. There are two glycols which are commonly used: Ethylene glycol (EG) and propylene glycol (PG). Of the two, EG has slightly better thermal properties and can cool in a broader temperature range. However, it is highly toxic and not usable in all applications. In those cases, PG is a good alternative. We recommend mixing with distilled water; the best mix rate is 50/50.

Circulating Fluids – Mixes

Mixes are offered as a convenience and are made up of one or more of the fluids, described above, like a mix of ethylene glycol, water and algaecide. They are usually sold in volumes that make sense for filling common-sized equipment like chillers.

NOTES

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