Version 1.4 - 18.09.09

Результаты исследования производительности Unistat®

huber

high precision thermoregulation

Вы все правильно установили?

Зачем мы публикуем результаты исследования производительности Unistat®?

Мы публикуем результаты исследования для того, чтобы показать, насколько качество установки каждого компонента влияет на эффективность работы системы в целом. Уже первые примеры сборника дают четкое представление о преимуществах правильной установки внешней системы. Внесение ряда недорогих, но высоко эффективных изменений, позволит повысить производительность вашей системы в 1,5 раза.

Следуя простым рекомендациям, вы можете улучшить термодинамические показатели системы. Это позволить вернуть инвестиции в оборудование гораздо быстрее, чем вы ожидаете.

Нам хотелось бы, чтобы вы извлекли выгоду из наших знаний в области экономичного и высокоэффективного терморегулирования и получили представление о том, каким должен быть результат, сравнив производительность вашей системы с производительностью Unistat® в сочетании с различными реакторами. Это поможет вам принять решение, основанное не только на теоретических вычислениях, но и на проверенных результатах. Если вы используете оптимизированную установку, это также поможет вам сэкономить время и сократить потребление энергии с помощью HUBER Unistat®.
Нижеследующие вопросы требуют положительных ответов. В противном случае экономия ваших финансов напрямую зависит от того, какое количество отрицательных ответов вы сможете заменить положительными.
Проведите небольшой предварительный анализ:

- Внутренний диаметр коннектора жидкостного насоса равен внутреннему диаметру шлангов, подключенных к внешней системе?
- Шланги и коннекторы хорошо изолированы?
- Все шланги имеют длину не более 3м в обоих направлениях. Если НЕТ, то вы используете вместо них изолированные жесткие трубы из нержавеющей стали?
- Коннекторы вашей внешней системы (как правило, реактора) имеют такой же внутренний диаметр, как шланги?
- Для внешней системы вы использовали опцию «Идентификация параметров» в меню блока управления Unistat® Pilot?
- Установлено оптимальное значение скорости насоса? (в термостатах с такой функцией)

Ответы порождают другой, не менее интересный вопрос:

Почему необходимо использовать Unistat®, а не более дешевый традиционный термостат с открытой ванной? Чем это выгоднее для вас?

- Диапазон рабочей температуры используется в полном объеме, особенно температуры нижней границы диапазона. Кривая охлаждения не становится асимптотой до тех пор, пока не достигнуто заданное значение (ключевое слово: удельная мощность охлаждения).
- В сравнении с другими циркуляторами, при использовании Unistat® потребление охлаждающей воды сокращается на 2/3.
- Минимальный объем заполнения Unistat® означает, что для заполнения самого прибора вы будете использовать гораздо меньше теплоносителя, при этом плотность мощности охлаждения будет повышаться автоматически.the cooling power density rises automatically.
- Использование жидкости Dw-Therm позволяет работать в диапазоне от -90ºC до +200ºC без смены теплоносителя. Теперь вы можете приобретать только один теплоноситель.
- Наши новые улучшенные изолированные шланги помогут предотвратить нежелательное понижение давления в системе. В результате скорость потока во внешнюю систему увеличится, несмотря на отсутствие огромных насосов, вырабатывающих тепло, которое в свою очередь снижает мощность охлаждения. Это имеет особенно важное значение при работе на низких температурах рабочего диапазона. Результат: экономия энергии, завершение процесса за более короткий промежуток времени, чем это было возможно ранее.
- Преимущества Unistat®: отсутствие испарений с поверхности ванны и окисления теплоносителя. При работе прибора на низких температурах даже в течение продолжительного времени не происходит абсорбции влаги теплоносителем. Экономия огромного количества денег и времени обуславливается отсуствием необходимости утилизировать использованный теплоноситель.
- Используя приборы HUBER с натуральными хладагентами, вы не оставляете шансов парниковому эффекту. С 1993 года, за 6 лет до официального запрета, компания HUBER добровольно прекратила использование CFC и H-CFC фреонов и стала первой компанией, производящей приборы с озоносберегающими хладагентами (хладагентами «простой замены»). Сегодня, в преддверии нового обсуждения ограничений в целях защиты озонового слоя, HU-BER, как и прежде, на 6 лет раньше, предлагает экологически безопасное решение для ваших вложений.
- Последнее и самое важное: ваша работа будет протекать значительно быстрее!

Вы все правильно установили?

Таким образом, ответом на размышления о преимуществах использования Unistat® будет экономичность и экологическая безопасность.
Проведите сравнение результатов исследований и вы обнаружите существенные различия между Unistat® и другими термостатами с такой же мощностью охлаждения.

Откуда эти различия?… давайте снова обратимся к примерам практического применения:

В первой установке мы использовали изолированные шланги M16x1 (#6084). Вторая установка выполнена с использованием шлангов M24x1,5 (#9325). В обоих случаях мы использовали один и тот же стеклянный реактор. Пожалуйста, сравните графики, и вы увидите разницу во времени, затраченном на выполнение работы каждой из систем.

Чтобы подтвердить полученный результат, мы изменили комплектацию систем и использовали реактор гораздо большего объема. Это изменение подтвердило эффективность воздействия высокой удельной мощности охлаждения Unistat®.

Какое значение это имеет для вас, как для пользователя? Давайте рассмотрим данный пример подробнее…

Что такое удельная мощность охлаждения?
Цитата: «это отношение мощности охлаждения к объему заполнения при заданной температуре и указанном объеме заполнения, где объем заполнения – это объем теплоносителя, необходимого для обычного использования лабораторного циркулятора, без учета объема теплоносителя во внешних контурах».

Доступная мощность охлаждения всегда указывается с расчетом на максимальную скорость насоса. Если бы мы указывали значение мощности охлаждения, скажем, при средней скорости, то эти данные давали бы неверное представление о доступной мощности охлаждения. Чем больше мощность насоса, тем меньше мощность охлаждения, доступная для эффективного использования.

Какую выгоду я могу извлечь из высокой удельной мощности охлаждения?
При использовании Unistat® с высокой удельной мощностью охлаждения, вам не придется охлаждать и нагревать излишнюю массу для достижения заданного значения, благодаря минимальному объему заполнения прибора, рубашки и шлангов.

Обратите внимание насколько минимален объем заполнения приборов Unistat®. С подробной информацией и техническими характеристиками вы можете ознакомиться на нашем сайте. Среди прочих примеров на сайте представлен Unistat® Tango с внутренним объемом заполнения всего 1,5 л; даже объем заполнения среднего Unistat® не превышает 5л.

Пример для вычисления:
Объем заполнения Unistat® 910w 4,3 л, мощность охлаждения 5,3 кВт при температуре -20°C. Значит, удельная мощность охлаждения Unistat® 910w составляет 1210 Вт/л. Произведя аналогичные расчеты для Unistat® 680w, определяем, что при мощности охлаждения 130 кВт при температуре 0°C и минимальном объеме заполнения 40л, удельная мощность охлаждения прибора составляет 3250 Вт/л.
Для того, чтобы убедиться в эффективности финансовых вложений, вам необходимо рассмотреть несколько параметров, однако, в качестве основного фактора всегда рассматривайте удельную мощность охлаждения (Вт/л). Это единственный показатель, являющийся достоверным основанием для сравнения ожидаемых показателей системы.

*DIN 12876-1

Вы все правильно установили?

Небольшое техническое отступление, поясняющее, почему мы делаем то, что делаем…

Одной из самых распространенных причин низкой теплопередачи и неустойчивого температурного контроля является использование неэффективных насосов, узких или ограничивающих внутренний диаметр соединительных шлангов, а также конфигурация внешнего кругооборота теплоносителя.
Понятно, что уже созданные насосы и внешний кругооборот теплоносителя невозможно изменить с легкостью, особенно в случае, когда речь идет о конструкции самой внешней системы, однако, поиск возможных изменений с целью увеличения скорости потока теплоносителя может привести к заметному повышению производительности системы. Наши насосы специально оснащены соединениями с таким диаметром, который гарантирует минимальное сопротивление потока при его максимальной скорости. Быстрая и простая проверка позволяет убедиться в том, что диаметр соединительных шлангов точно совпадает с диаметром соединений насоса Unistat® и вами используются действительно подходящие шланги.

Одно из распространенных заблуждение заключается в том, что важное значение имеет только высокое давление насоса. Однако, это не верно! Мы стремимся к тому, чтобы мощность охлаждения концентрировалась именно там, где это необходимо, а именно в процессе. Мы стремимся обеспечить максимально высокую скорость потока при минимально возможном давлении. (Q=m*cp*DeltaT).

Возможность использования стеклянного оборудования с максимальным рабочим давлением 0,5 бар также характеризует уровень нашей технологии. Используя дополнительный внешний байпас (VPC), мы можем контролировать давление непосредственно в чувствительной внешней системе и поддерживать жизненно важную скорость потока. Мы рады, что можем обеспечить высокую скорость потока в вашей внешней системе. Эти основные термодинамические характеристики присущи всем приборам HUBER.

В представленных ниже примерах мы попытались достичь оптимальных сочетаний с учетом реальных условий, встречающихся на практике. Это позволит вам увидеть, чего можно достичь при помощи различных сочетаний реактора и прибора. Изменения установки неизбежно влекут за собой изменения производительности системы. Мы не можем гарантировать аналогичной производительности вашей системы, если вы используете другое оборудование. Мы сохраняем за собой право вносить изменения в спецификации вследствие постоянного технического совершенствования оборудования. Мы прилагаем все усилия, чтобы обеспечить достоверность и точность информации, содержащейся в данном сборнике, однако мы не несем ответственности за возможные ошибки.

Мы будем рады, если вы захотите представить нам информацию о практическом применении внешних систем, подобных тем, которые вы увидите в данном сборнике... It takes two to Tango!

Version: 9/2009

Unistat®
petite fleur

Headline???

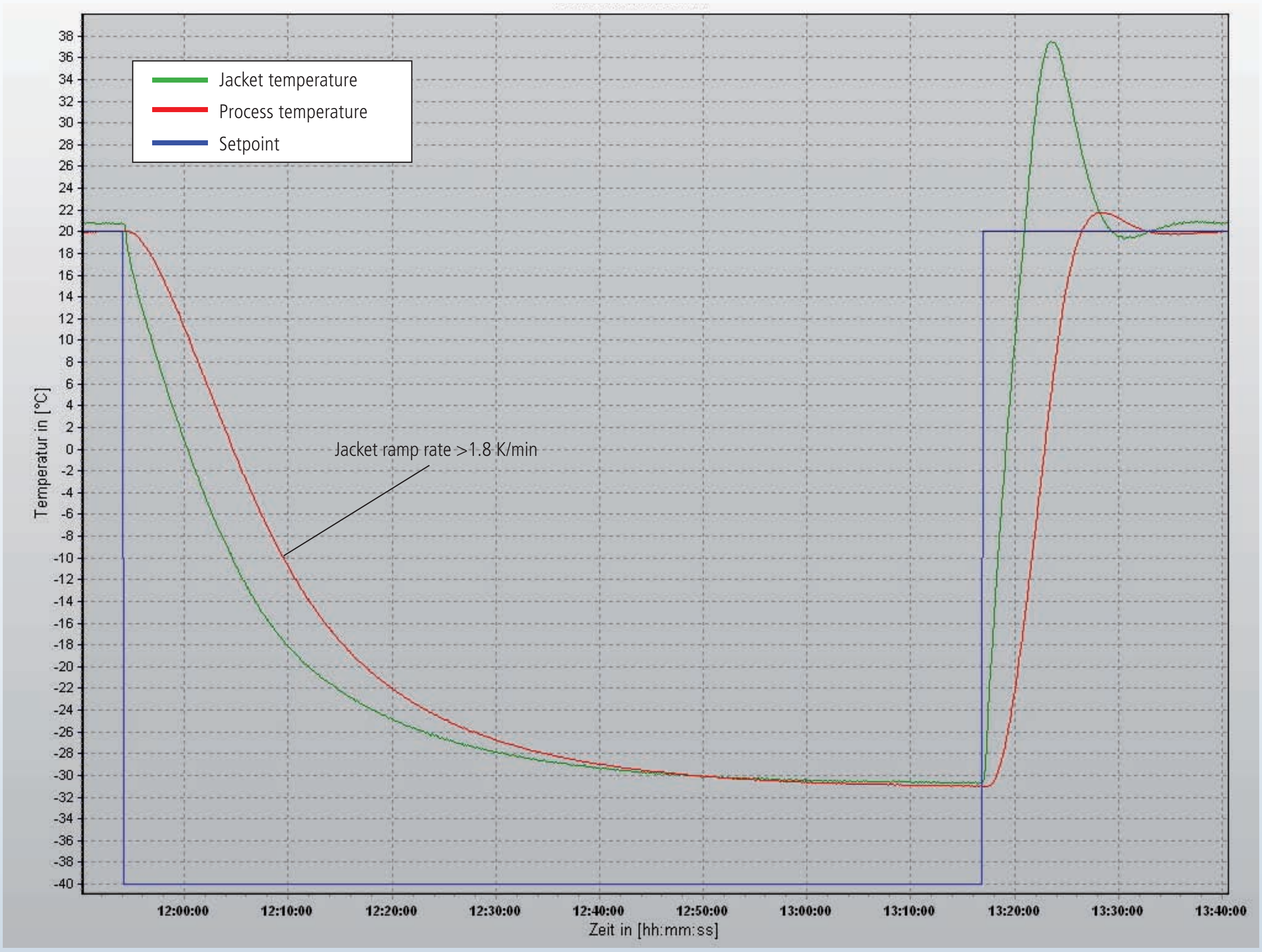
Requirement
This case study examines the lowest achievable process temperature that the Petite Fleur can take the contents of a 0.3-litre un-insulated reactor.

Method
The Petite Fleur (Baby Tango) was connected to the reactor via two 1-metre insulated metal hose. The reactor was filled with 0.2 litre Ethanol. A set-point of -40 was entered and the system left to run to its lowest achievable temperature.

Results
The Baby Tango shows that it is very efficient at transferring thermal energy and cools the process to -31 °C. The heat-up curve also demonstrates the power-transfer capabilities and results tight process control.

Setup details
Petite Fleur & Picoclave

Temperature range:	-40...200 °C
Cooling power:	0.48 kW @ 200…0 °C 0.27 kW @ -20 °C
Heating power:	1.5 kW
Hoses:	2x1 m; M16x1 (#9608)
HTF:	DW-Therm (#6479)
Reactor:	0.3 litre un-insulated glass pressure reactor
Reactor content:	200 ml Ethanol
Stirrer speed:	900 rpm
Control:	process



Version: 9/2009

Unistat® petite fleur

Controlling a Büchi Ecoclave

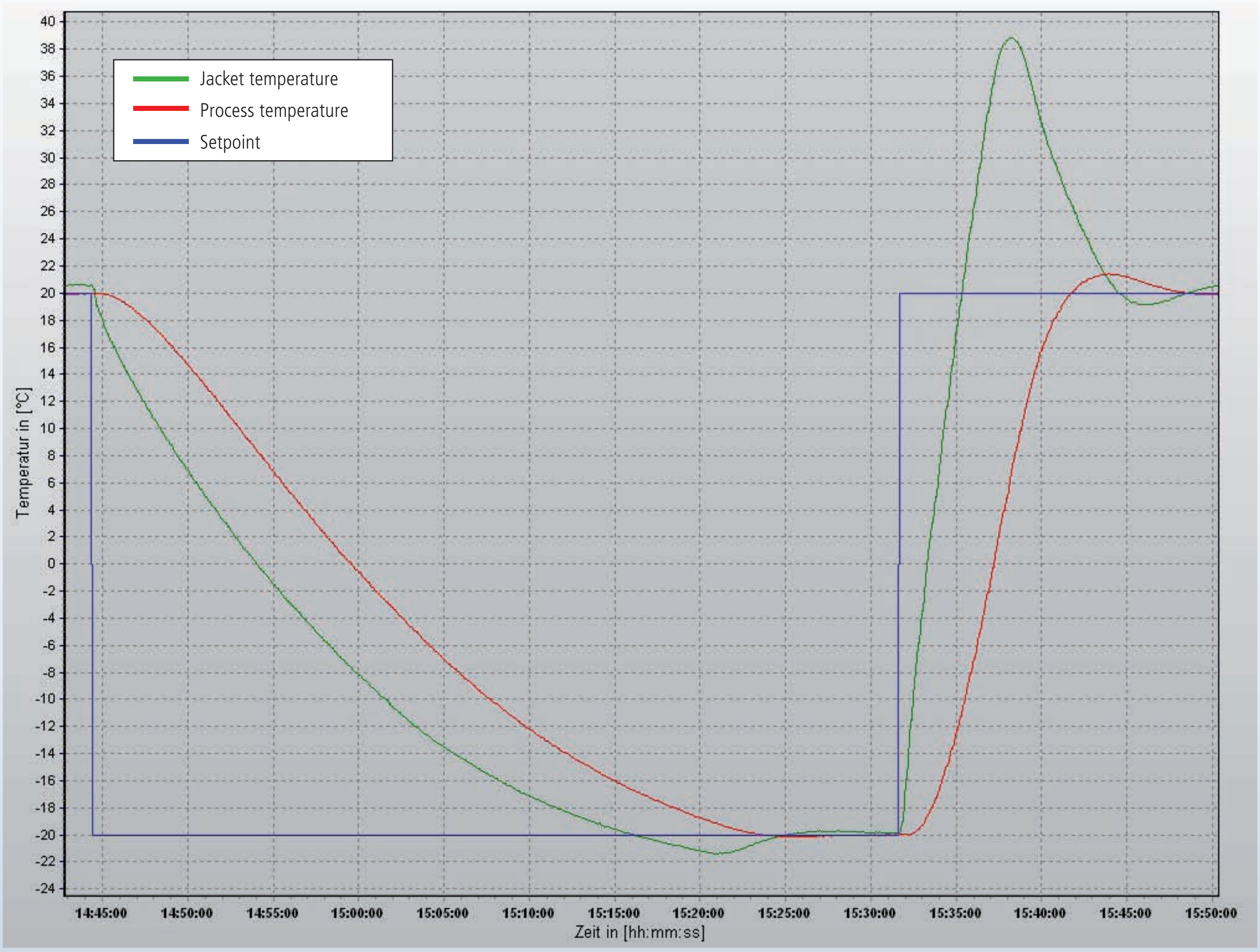
Requirement
This case study looks at the ability of the Unistat® Petite Fleur to control the process temperature in a 1-litre "Büchi Ecoclave" between 20 °C and -20 °C

Method
The Büchi Ecoclave and Unistat® Petite Fleur are connected with two 1-metre insulated metal hoses. The Büchi Ecoclave is filled with 0.5 litre of Ethanol and Ethanol is used as the HTF.

Results
The graphic shows the outstanding performance of the Petite Fleur cooling the contents of a 0.3 litre jacketed glass Büchi Glas Ecoclave through 40 K from 20 °C to -20 °C and back again. The "Baby Tango" is truly a powerful performer. All data is recorded with the pump on MAXIMUM speed.

Setup details
Petite Fleur & Büchi Ecoclave

Temperature range:	-40...200 °C
Cooling power:	0.48 kW @ 200…0 °C 0.27 kW @ -20 °C
Heating power:	1.5 kW
Hoses:	2x1 m; M16x1
HTF:	Ethanol (#9608)
Reactor:	300 ml un-insulated glass pressure reactor
Reactor content:	0.25 litre
Stirrer speed:	~ 600 rpm
Control:	process



Version: 9/2009

Unistat®
petite fleur

Headline???

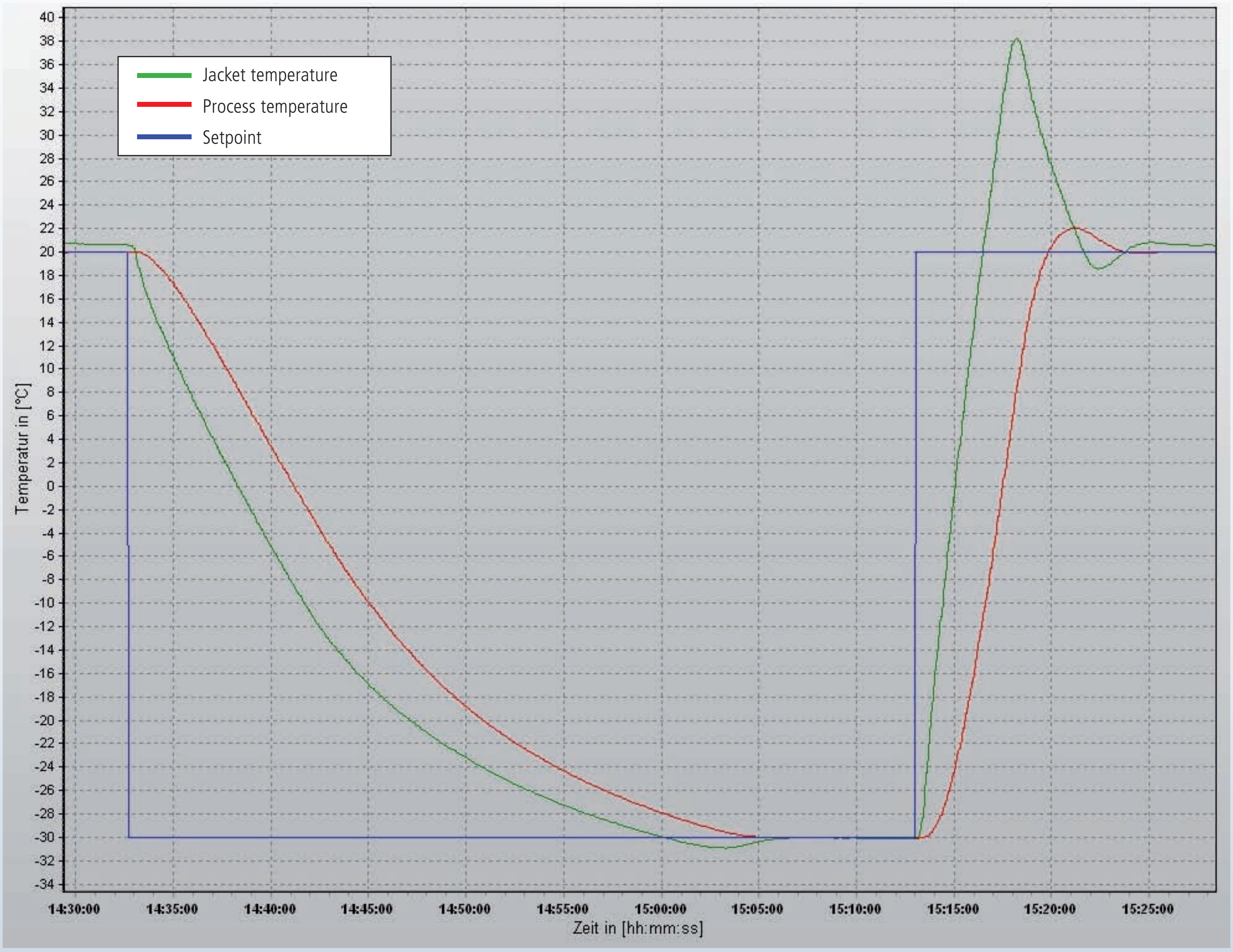
Requirement
This case study looks at the repeatability of control as the Unistat® Petite Fleur cycles the process temperature of a 2-litre un-insulated glass reactor.

Method
The Unistat® Petite Fleur is connected to the reactor with two insulated metal 1-metre hoses. The Petite Fleur is then programmed to cycle between low and high temperatures.

Results
The repeatability of precise control can be seen as well as the minimum achievable process temperature. Each cycle is identical giving the operator the confidence of predictable performance.

Setup details
Petite Fleur & Schlee GmbH

Temperature range:	-40...200 °C
Cooling power:	0.48 kW @ 200…0 °C 0.27 kW @ -20 °C
Heating power:	1.5 kW
Hoses:	2x1 m; M16x1 (#9608)
HTF:	Ethanol
Reactor:	0.5 litre un-insulated glass reactor
Reactor content:	375 ml M90.055.03 (#6259)
Stirrer speed:	160 rpm
Control:	process



Unistat®
petite fleur

Controlling a Büchi Picoclave

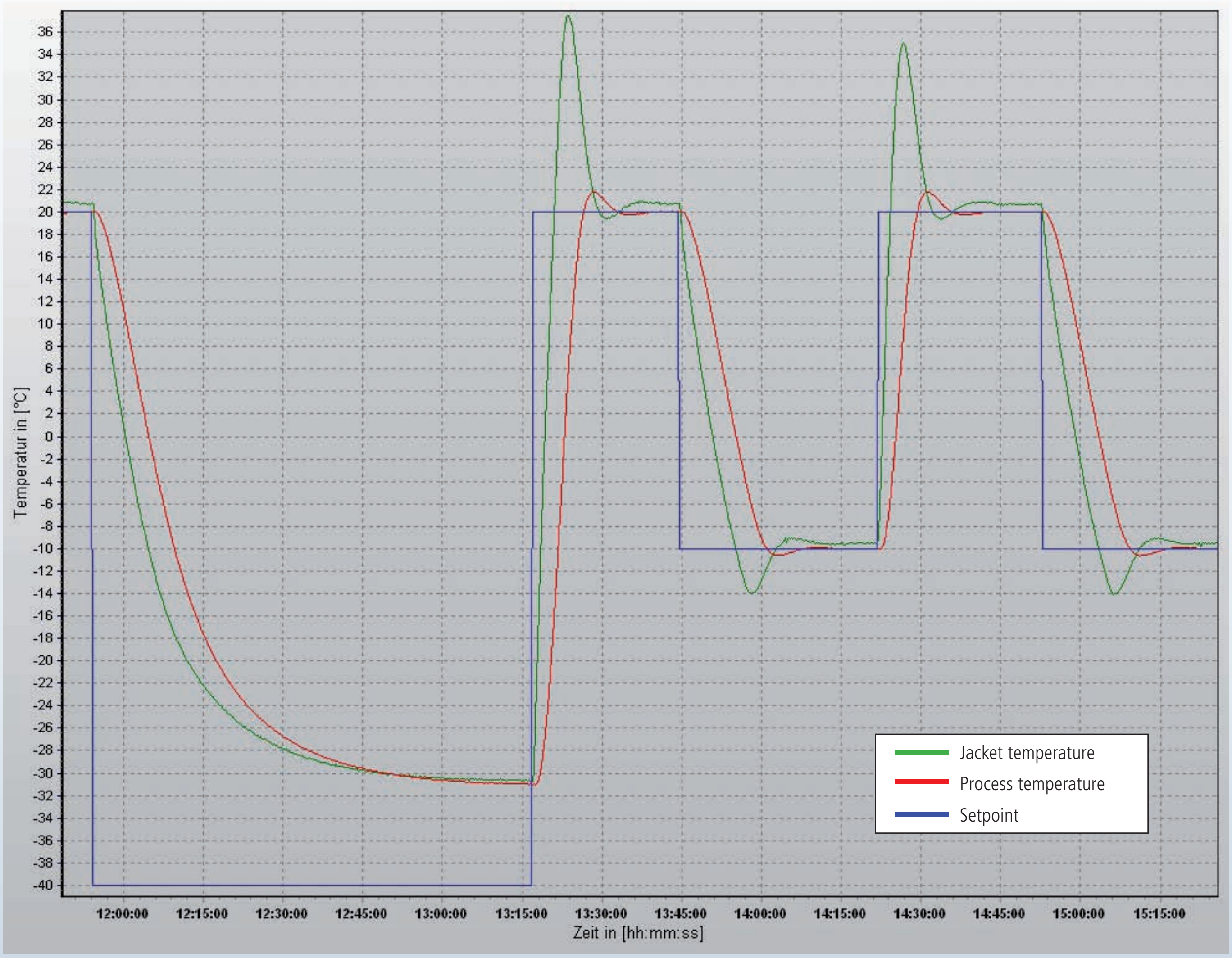
Requirement
This case study looks at the repeatability of control as the Unistat® Petite Fleur cycles the process temperature of a Büchi Picoclave.

Setup details
Petite Fleur & Büchi Picoclave

Temperature range:	-40...200 °C
Cooling power:	0.48 kW @ 200…0 °C 0.27 kW @ -20 °C
Heating power:	1.5 kW
Hoses:	2x1m; M16x1 (#9325)
HTF:	Ethanol
Reactor:	0.3 litre un-insulated jacketed glass pressure reactor
Reactor content:	0.2 litre Ethanol
Stirrer speed:	900 rpm
Control:	process

Method
The Unistat® Petite Fleur is connected to the reactor with two insulated metal 1-metre hoses. The Petite Fleur is then programmed to cycle between low and high temperatures.

Results
The new Unistat® "Petite Fleur" brings the Tango Technology at a lower cost to smaller reactors. The graphic shows the performance of the Petite Fleur when connected to a 0.3-litre Büchi Glas Picoclave demonstrating the lowest achievable process temperature and the rapid ramping rate over a temperature change of 30 K from 20 °C to -10 °C. All data is recorded with the pump on MAXIMUM speed.



Version: 9/2009

Unistat®
Tango Nuevo

Power vs. Power Transfer

Requirement
This study is to demonstrate that thermal transfer is THE key component in temperature control. In this case study we compare a Unistat® Tango Nuevo to a more powerful machine.
Both systems were tested under identical ambient conditions and using the same peripherals (insulated reactor, HTF etc.).
The technical data is taken from published materials in the public domain and is in accordance with DIN 12876.

Method
The units were fitted to a 1-litre un-insulated glass pressure reactor with M24x1.5 hoses.
The HTF system (thermostat, tubing & reactor jacket) was filled with DW-Therm and the reactor contained 0.75 litre of "M90.055.03" silicon oil (Specific heat capacity of 0.36 kcal / kg °C) to act as a thermal load/process simulation.

Results
The results clearly demonstrate that the power transfer from the (pseudo) "dynamically sealed" system is inefficient resulting in slower ramp rates despite having nearly twice the (published) cooling power of the Tango Nuevo.

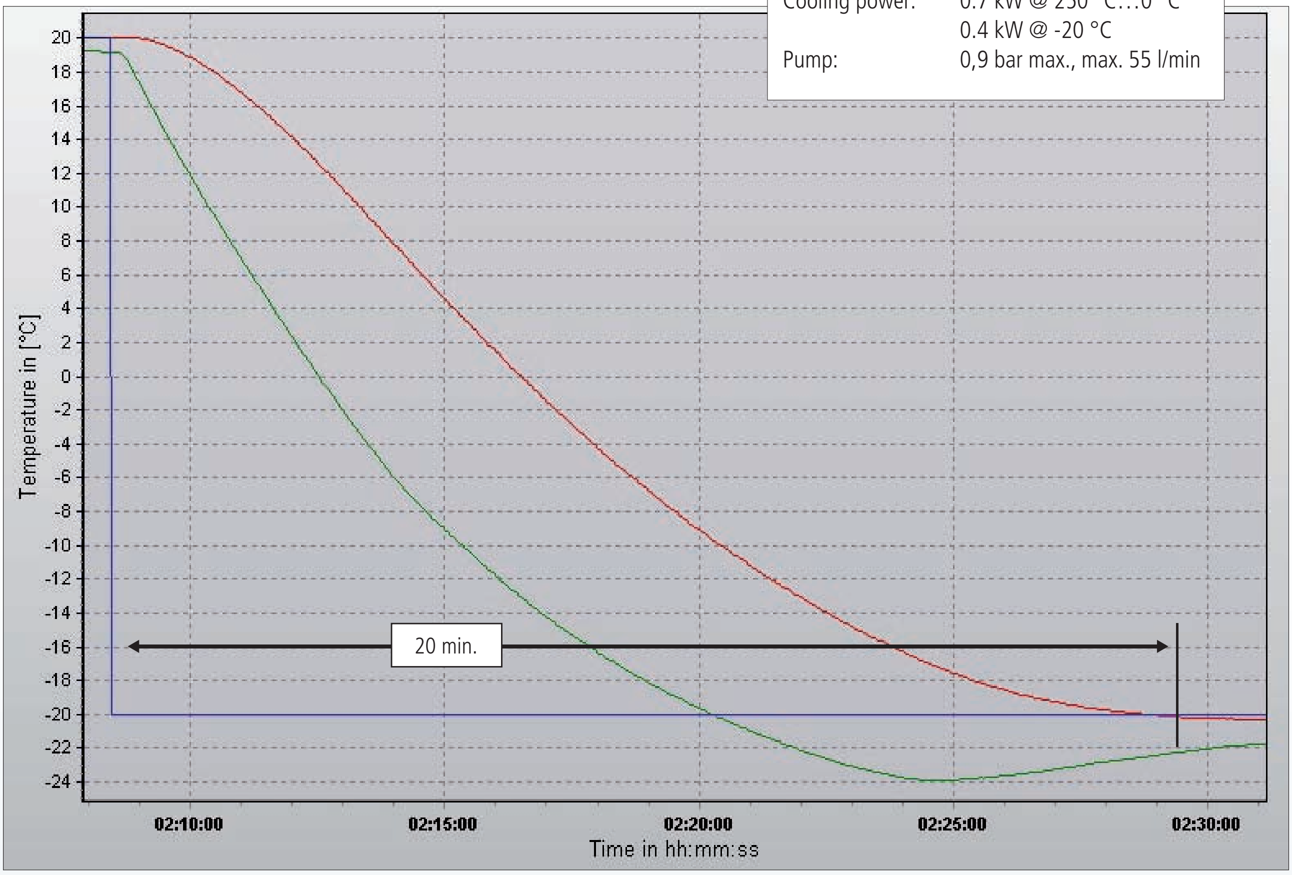
However, we were surprised at the gap in performance and investigated further.
The causes for such large losses can partially be seen in the pump specification in having high pressure yet low flow rate. Moisture absorption into the HTF during the operation of the "dynamically sealed" system via "breather" and "venting" valves may have caused ice build-up on the evaporator impairing performance. We were unable to confirm the published cooling power of the "dynamically sealed" system in tests carried out by certified refrigeration specialists.

Technical details and dimensions are subject to change. No liability is accepted for errors or ommisions.

Results

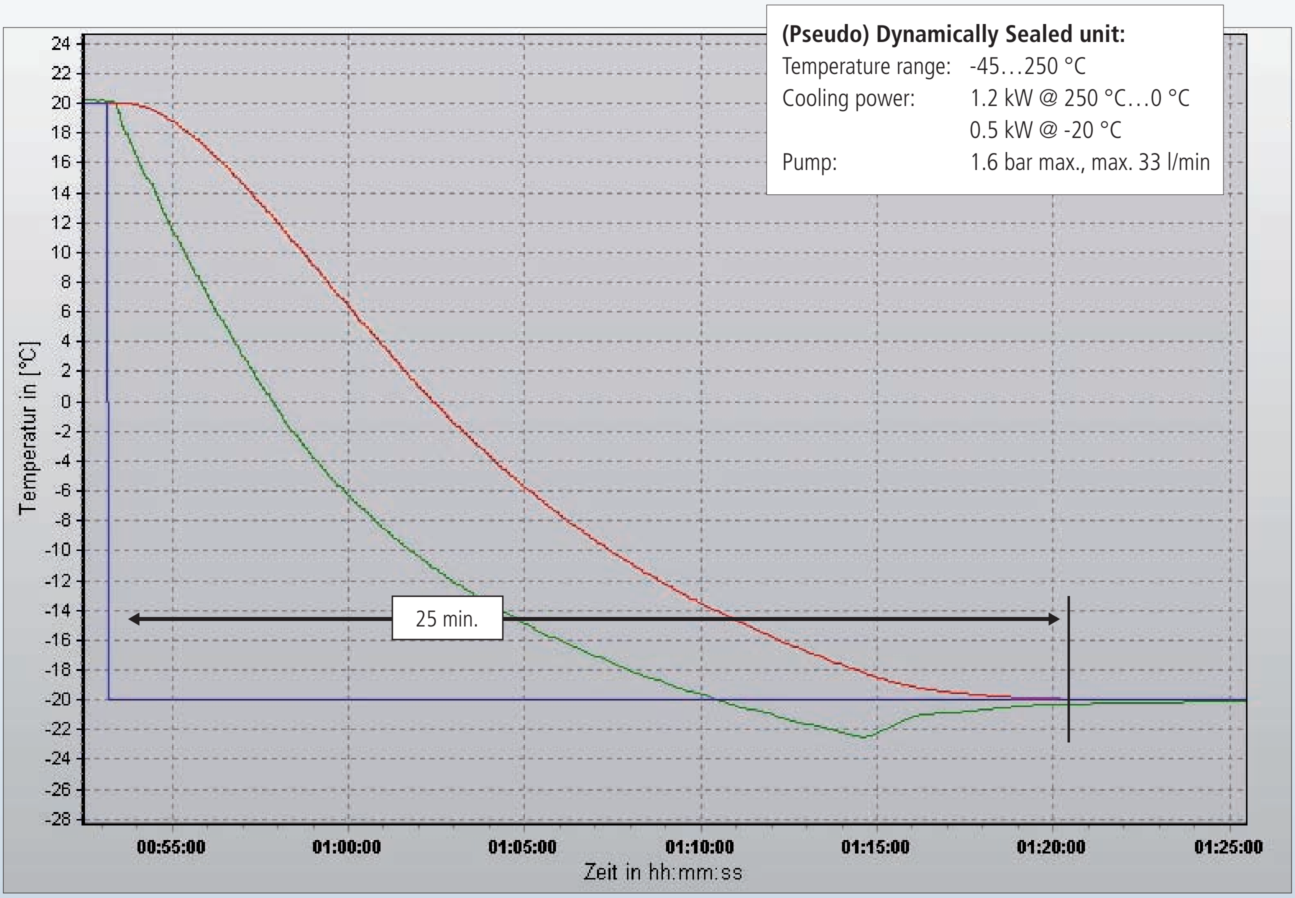
Unistat® Tango Nuevo:

Temperature range:	-45…250 °C
Cooling power:	0.7 kW @ 250 °C…0 °C
	0.4 kW @ -20 °C
Pump:	0,9 bar max., max. 55 l/min



(Pseudo) Dynamically Sealed unit:

Temperature range:	-45…250 °C
Cooling power:	1.2 kW @ 250 °C…0 °C
	0.5 kW @ -20 °C
Pump:	1.6 bar max., max. 33 l/min



Unistat® Tango Nuevo

Exothermic reaction at 20 °C in a 2-litre reactor

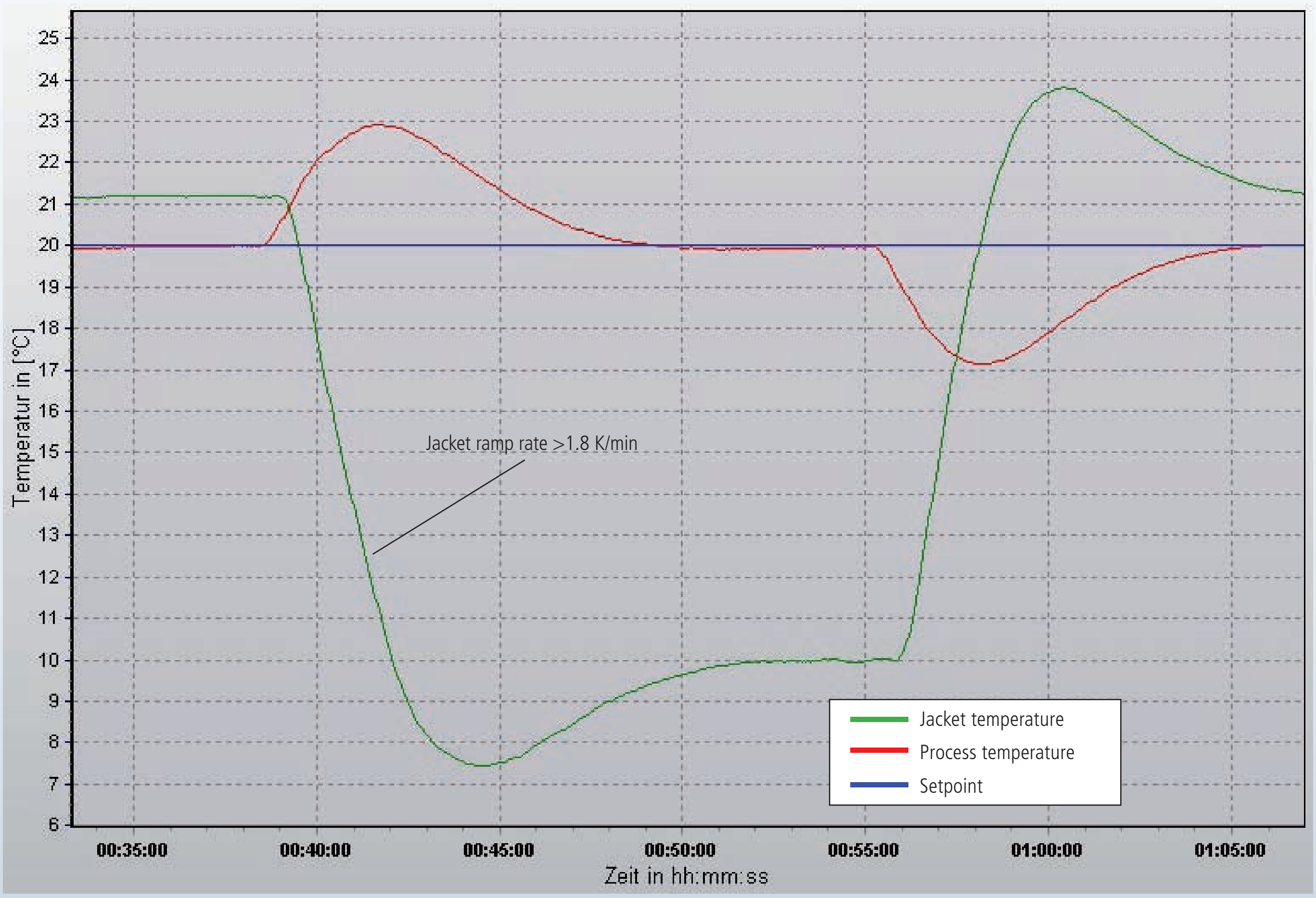
Requirement
This case study looks at the response capability of the Unistat® Tango Nuevo and the resulting impact on process temperature control.

Method
The Unistat® Tango Nuevo was connected to a 2-litre un-insulated glass reactor using two 1-metre insulated metal hoses. The reaction was simulated using an electric heater placed inside the ractor contents.

Results
An exothermic reaction of 50 W (43 kcal / hr) is simulated with an immersion heater at 20 °C in an un-insulated 2-litre glass reactor. The process curve shows how fast the Unistat® Tango Nuevo compensates for a sudden rise in process temperature. The rapid generation of a wide ΔT to induce heat flow to bring the simulated reaction under control can be seen in the response curves.

Setup details
Unistat® Tango Nuevo & DDPS reactor

Temperature range:	-45...250 °C
Cooling power:	0.7 kW @ 250…0 °C 0.4 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre un-insulated glass pressure reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Unistat® Tango Nuevo

Heating and Cooling Ramps with a 1-litre Büchi reactor

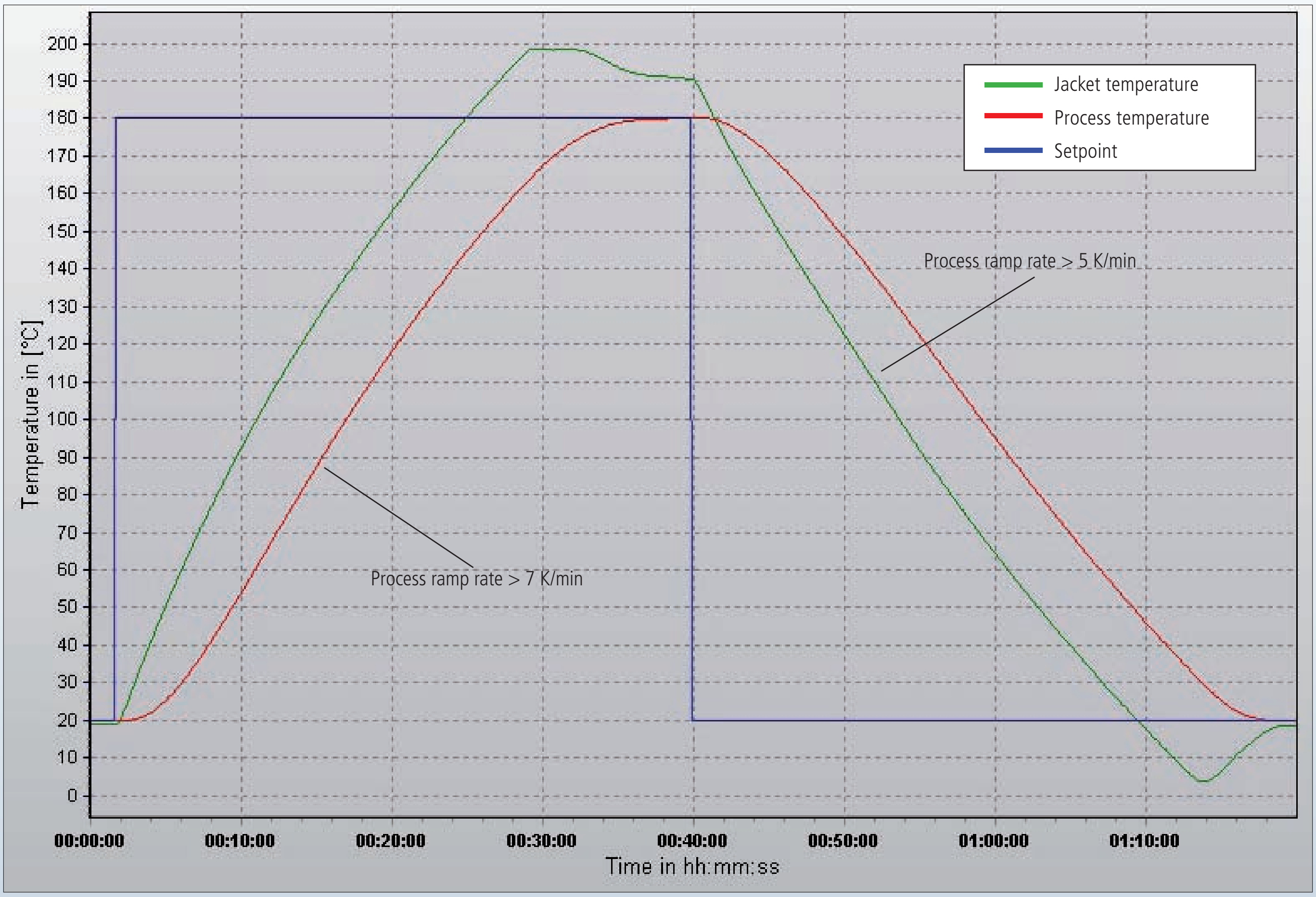
Requirement
This case study looks at the speed at which the Unistat® Tango Neuvo can heat and cool the process in a 1-litre un-insulated glass pressure reactor.

Method
Using two large diametre (M24x1,5 DN12) insulated metal hoses, the reactor was connected to the Unistat® Tango Nuevo. The reactor was filled with 0.75-litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
Efficient thermal transfer made possible by the low flow resistance of the wide bore tubing coupled with the highly efficient thermal transfer capabilities of the Unistat® Tango Technology results in a rapid ramping rate and extremely stable control. The diagram illustrates a heating curve from 20 °C to 180 °C in a time of 37 minutes and back to 20 °C in 38 minutes. The process temperature reached both set-points without any overshoot demonstrating the capability of the controller to ramp temperatures with speed and accuracy.

Setup details
Unistat® Tango Nuevo & Büchi reactor (büchiglasuster)

Temperature range:	-45...250 °C
Cooling power:	0.7 kW @ 250…0 °C 0.4 kW @ -20 °C
Heating power:	1.5 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre un-insulated glass pressure reactor glass pressure reactor
Reactor content:	0.75 litre M90.055.03 (#6259)
Stirrer speed:	500 rpm
Control:	process



Version: 9/2009

Unistat® Tango Nuevo

Heating and Cooling ramp, 1-litre Glas-Keller reactor

Requirement

This case study looks at how well the Tango Nuevo controls the process temperature inside a 1-litre reactor.

Method

Using two large diametre (M24x1,5 DN12) insulated metal hoses, the reactor was connected to the Unistat® Tango Nuevo. The reactor was filled with 0.75-litre of "M90.055.03", a Huber supplied silicon based HTF.

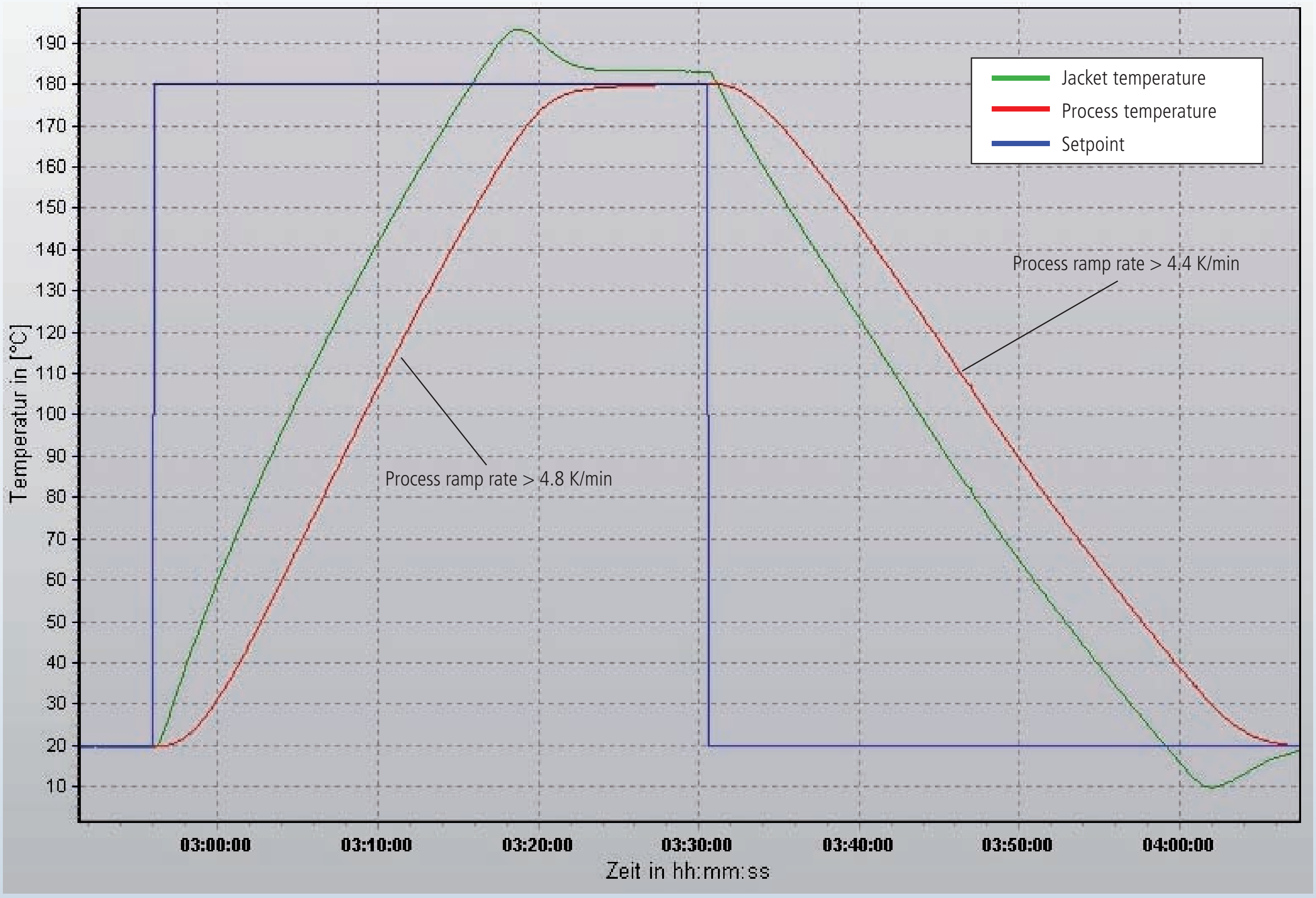
Results

Efficient thermal transfer made possible by the low flow resistance of the wide bore tubing coupled with the highly efficient thermal transfer capabilities of the Unistat® Tango Technology results in a rapid ramping rate and extremely stable control.

Setup details

Unistat® Tango Nuevo & Glas Keller reactor

Temperature range:	-45...250 °C
Cooling power:	0.7 kW @ 250…0 °C 0.4 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre vacuum insulated jacketed glass pressure reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process



Setup details
Unistat® 405w & HWS reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 0 °C
	0.7 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	5 litre glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process

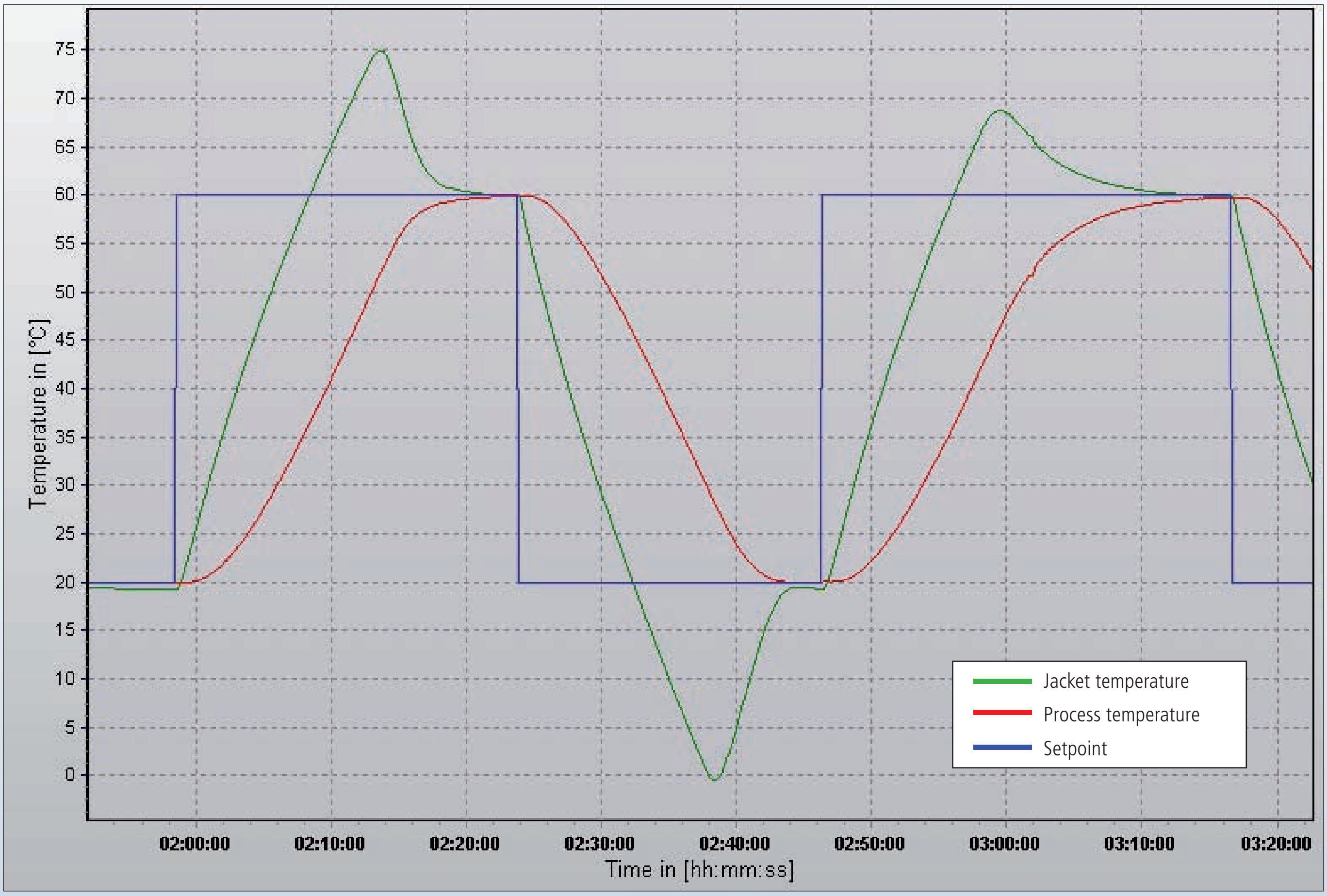
Unistat® 405w

Periodic and Aperiodic difference

Requirement
A standard feature of the "Unistat® Pilot" is to choose "fast, small overshoot" or "without overshoot" when reaching a setpoint.
This case study looks at the ability of the Unistat® 405w to control the process temperature in a 5-litre HWS un-insulated glass reactor underthese two different control dynamics, "Fast-with overshoot" or "No overshoot".

Method
The reactor and Unistat® 405w are connected using two 1-metre insulated metal hoses and the reactor is filled with 3.75 litre of "M90.055.03", a silicon based HTF. The Unistat® controls the temperature at 20 °C and then a new set-point of 0 °C is entered.

Results
The graphic shows the differences in performance between these settings. In this test the Unistat® 405w is programmed to alternate between 20 °C and 60 °C. The first process curve (fast, small overshoot) reaches 60 °C in just 25 minutes with the second process curve (without overshoot) takes 31 minutes to reach the setpoint. It can be seen that the overshoot is very minimal in the "fast, small overshoot" mode.



Version: 9/2009

Unistat® 405w

5-litre HWS glass reactor

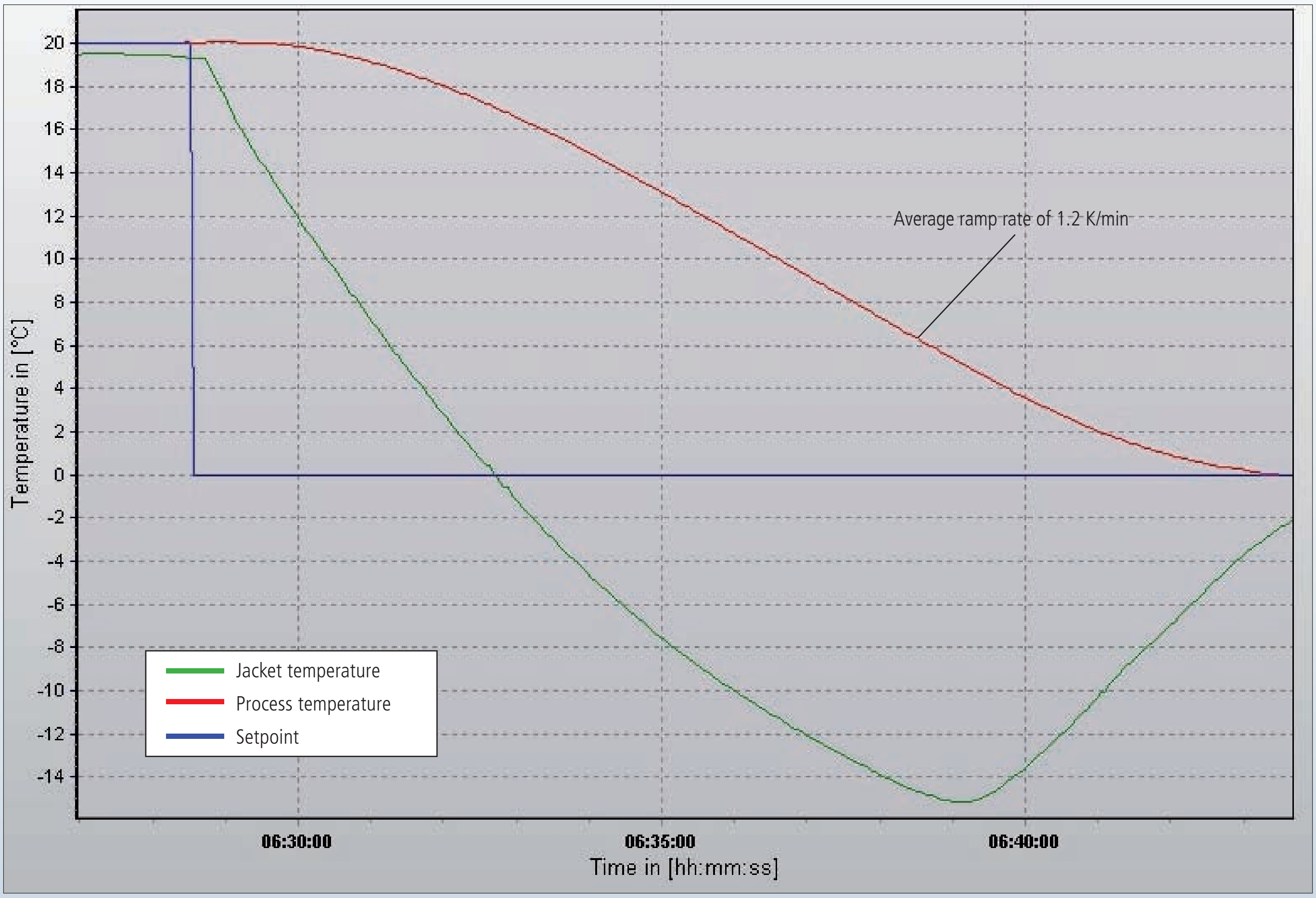
Requirement
This case study looks at the ability of the Unistat® 405w to control the process temperature in a 5-litre HWS un-insulated glass reactor.

Method
The reactor and Unistat® 405w are connected using two 1-metre insulated metal hoses and the reactor is filled with 3.75 litre of "M90.055.03", a silicon based HTF. The Unistat® controls the temperature at 20 °C and then a new set-point of 0 °C is entered.

Results
The process reaches 0 °C from 20 °C in just 17 minutes with no under or overshoots of the process set-point temperature. It is clearly seen how the jacket temperature rapidly ramps the jacket first down to pull the process towards target temperature then back up so the process temperature meets exactly the set-point.

Setup details
Unistat® 405w & HWS reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 0 °C 0.7 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	5 litre glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 405w & Glas-Keller reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 250…0 °C 0.7 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre jacketed glass reactor
Reactor contents:	0.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process

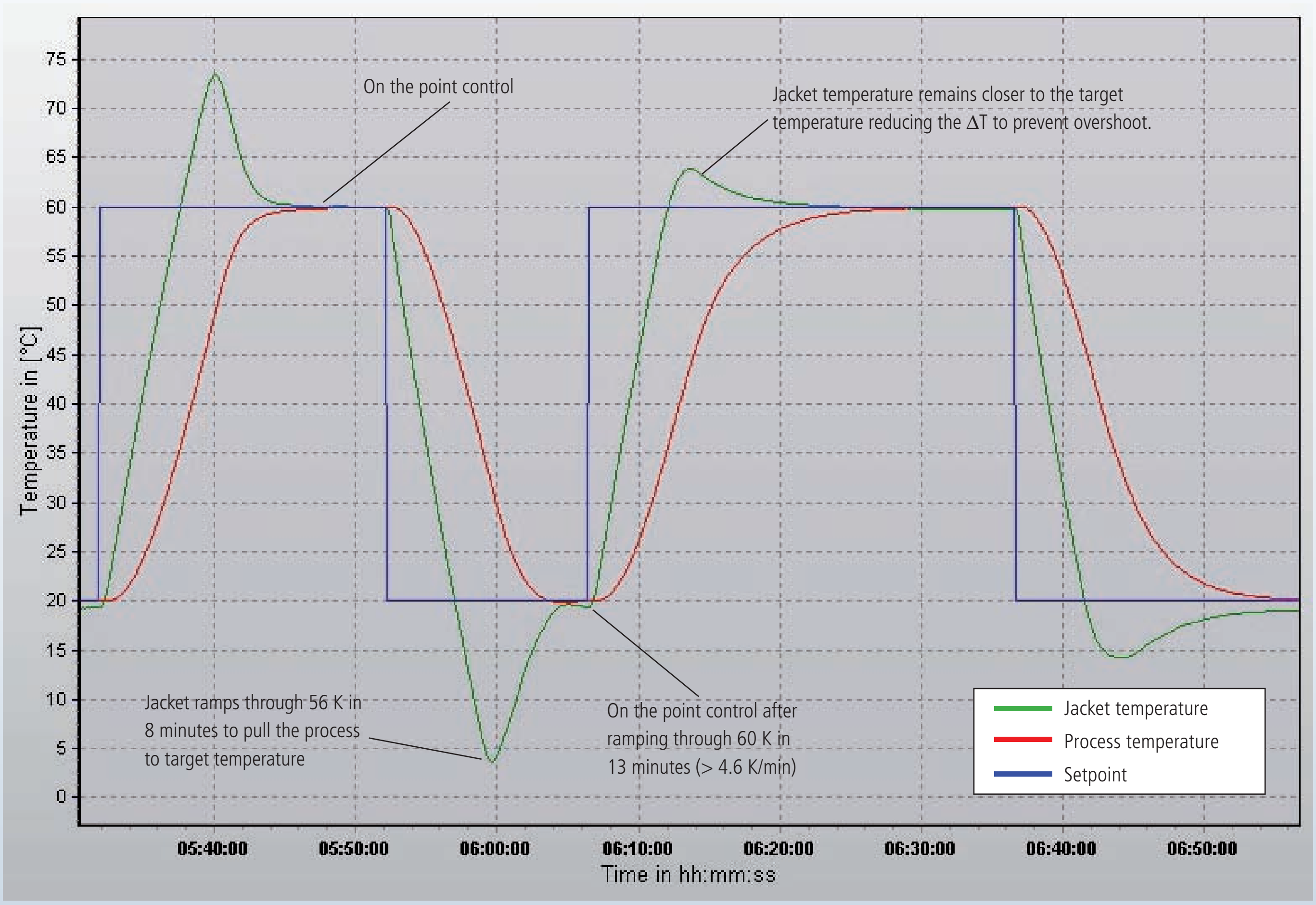
Unistat® 405w

Heating and cooling a Glas-Keller 1-litre glass reactor

Requirement
This case study examines the fast response of a Unistat® 405w controlling the process temperature inside a 1-litre un-insulated glass reactor from the company "Glas-Keller" under two different control dynamics, "Fast-with overshoot" or "No overshoot".

Method
The Unistat® 405w is connected to the Glas-Keller 1-litre reactor with two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a silicon based HTF.

Results
The first curve allow a small overshoot while the second two are "without overshoot". It can be seen that even allowing for an overshoot, the control is so tight the overshoot in the first curve is negligible.



Version: 9/2009

Unistat® 405w

Cooling a Glas-Keller 1-litre reactor from 20 °C to -20 °C

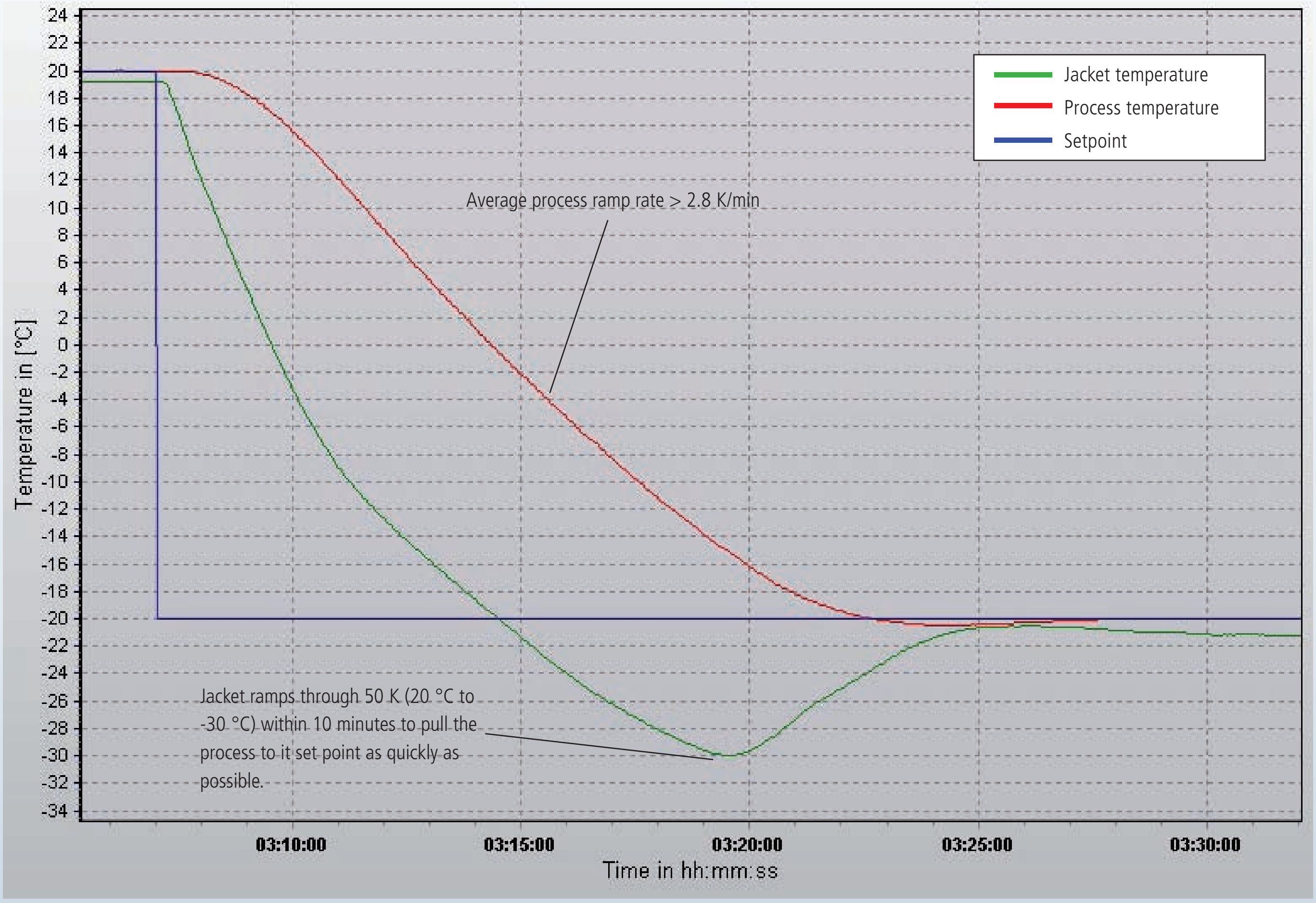
Requirement
This case study examines the fast response of a Unistat® 405w controlling the process temperature inside a 1-litre un-insulated glass reactor from the company "Glas-Keller".

Method
The Unistat® 405w is connected to the Glas-Keller 1-litre reactor with two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a silicon based HTF and controlled from a process sensor located inside the reactor.

Results
It can be seen that the Unistat® 405w quickly cools the jacket temperature to to rapidly cool the process to -20 °C from 20 °C. The process reaches the new set-point rapidly with negligible overshoot before being controlled precisely at -20 °C The ramp rate over the temperature change is almost linear at an average speed > 2.8 K / min taking 14 minutes to reach -20 °C.

Setup details
Unistat® 405w & Glas-Keller reactor

Temperature range:	-45...250 °C
Cooling Power:	1.3 kW @ 250…0 °C 0.7 kW @ -20 °C
Heating Power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre jacketed glass reactor
Reactor contents:	0.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Technical details and dimensions are subject to change. No liability is accepted for errors or ommisions.

Setup details
Unistat® 405w & Glas-Keller reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 250…0 °C 0.7 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre vacuum jacketed glass reactor
Reactor contents:	0.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process

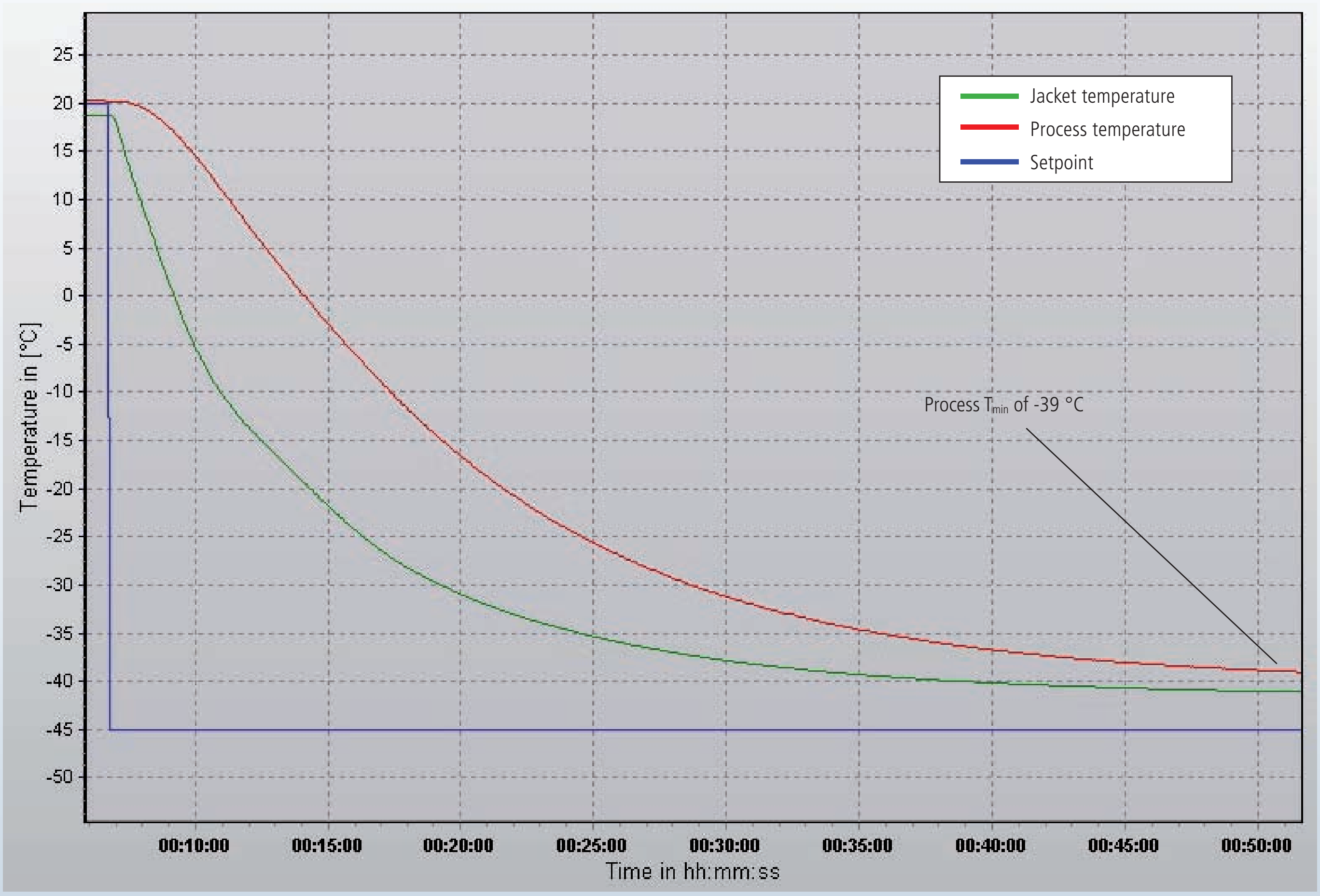
Unistat® 405w

Cooling a 1-litre reactor to T_{min}

Requirement
This case study determines the minimum process temperature that can be achived in a 1-litre Glas-Keller jacketed reactor with a Unistat® 405w under "process" control.

Method
The Unistat® 405w is connected to the Glas-Keller 1-litre reactor with two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a silicon based HTF.

Results
At first the Unistat® 405w rapidly cools the jacket temperature before the ramp rate slows and finally asymptoting at -41 °C cooling the process to its minimum temperature of -39 °C.



Version: 9/2009

Unistat® 405w

Heating & cooling a Glas-Keller 1-litre jacketed glass reactor between 20 °C and 180 °C

Requirement

This case study looks at the response to a wide set-point change in the process contained within a 1-litre Glas-Keller reactor.

Method

The Unistat® 405w is connected to the Glas-Keller 1-litre reactor with two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a silicon based HTF.

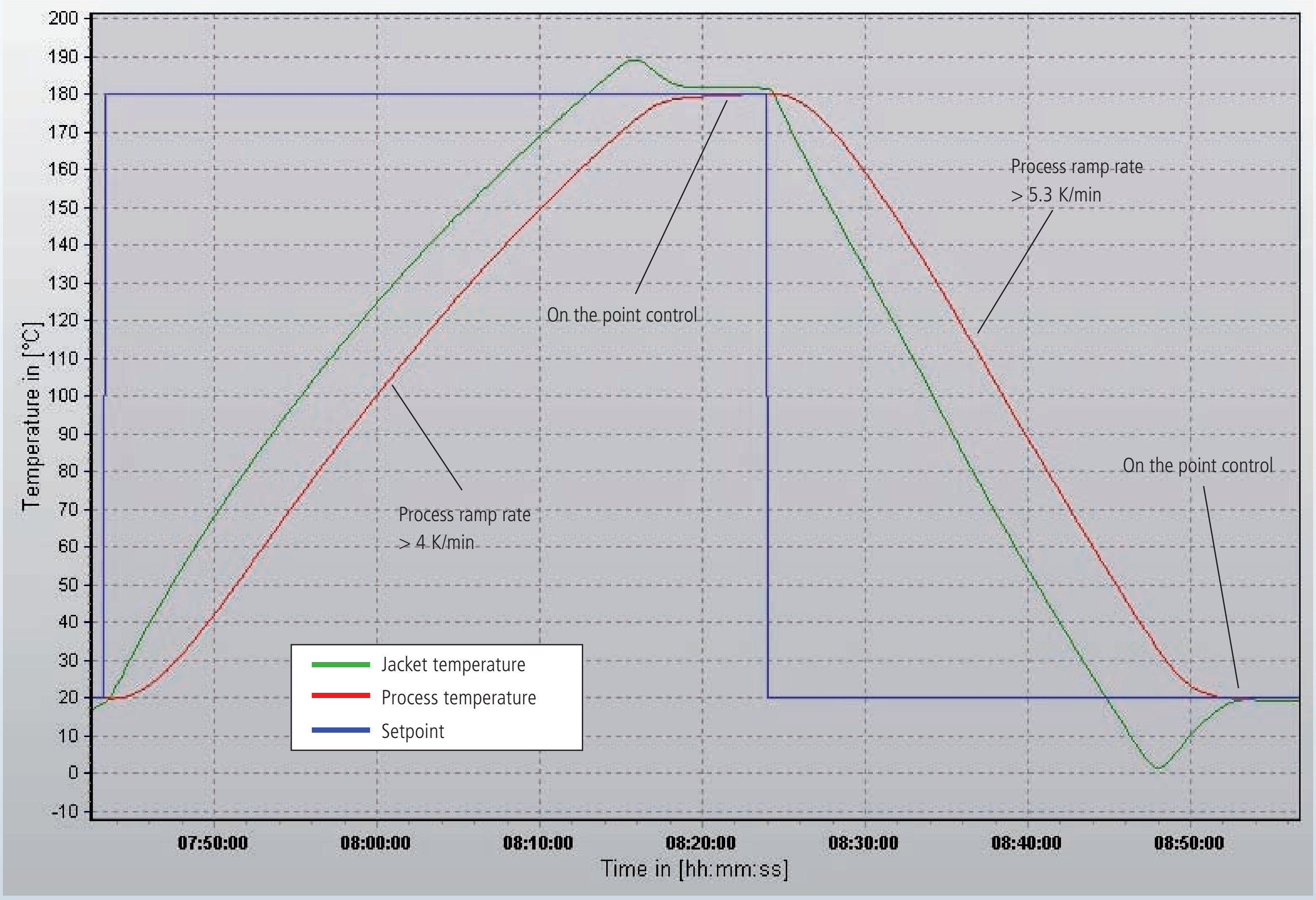
Results

The process is ramped through 160 K (20 °C to 180 °C within 40 minutes, ramp rate > 4 K / min). The cooling curve ramps at a rate of 5.3 K / min changing from 180 °C to 20 °C (160 K) in approximately 30 minutes.

Setup details

Unistat® 405w & Glas-Keller reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 250…0 °C 0.7 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre jacketed glass pressure reactor
Reactor contents:	0.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 405w & DDPS reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 250…0 °C 0.7 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor contents:	1.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	115 rpm
Control:	process

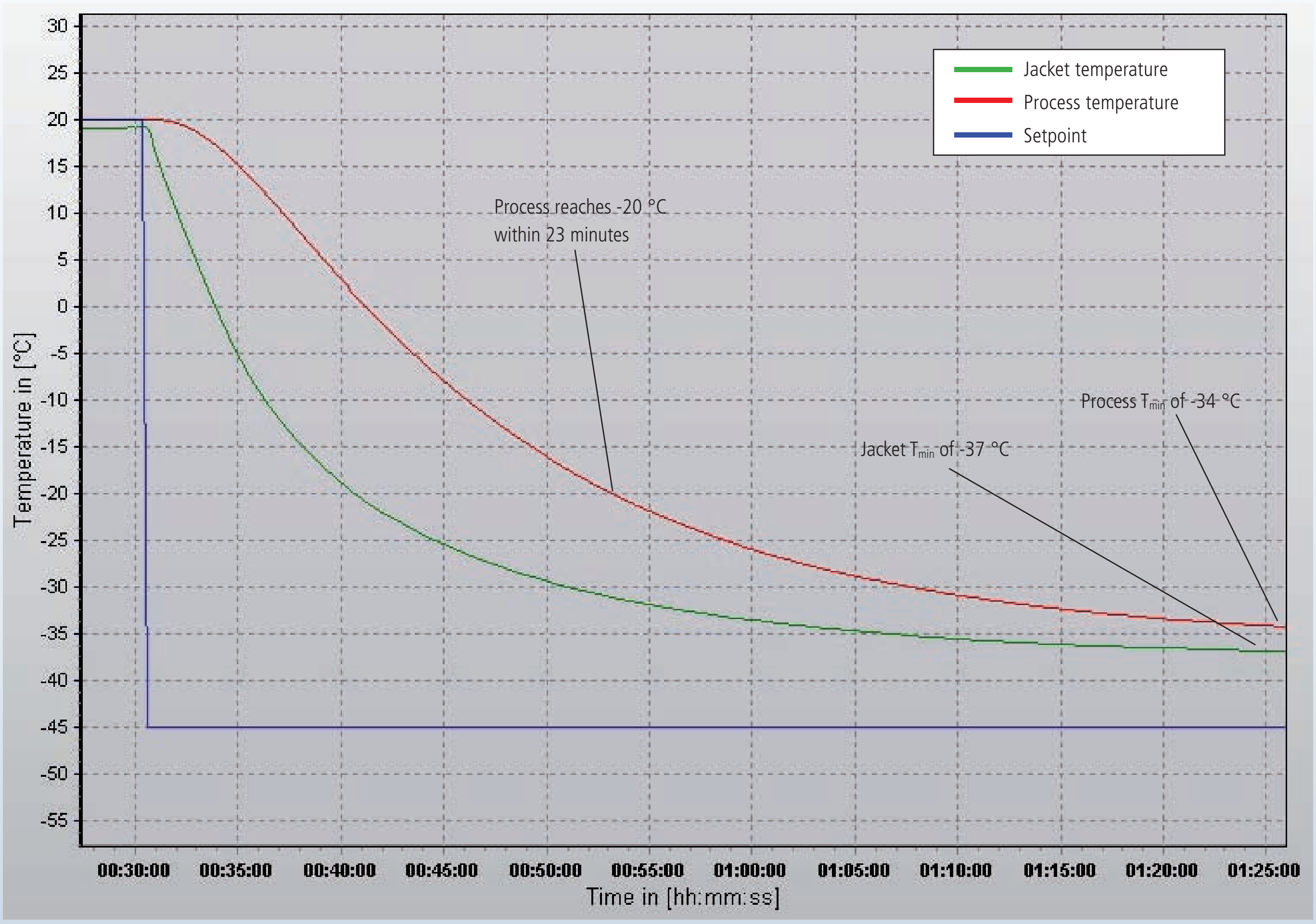
Unistat® 405w

Cooling a DDPS 2-litre glass reactor to T_{min}

Requirement
This case looks at the minimum temperature that a Unistat® 405w can take the process in a 2-litre DDPS jacketed reactor under "process" control.

Method
The Unistat® 405w was connected to the reactor using two 1-metre insulated metal hoses. The reactor was filled with 1.5 litre of "M90.055.03", a silicon based HTF.

Results
Process temperature reaches -20 °C from 20 °C (40 K) within 23 minutes (1.7 K / min) and asymptotes at -34 °C after 1 hour.



Unistat® 405w

Cooling a DDPS 2-litre jacketed glass reactor to -20 °C.

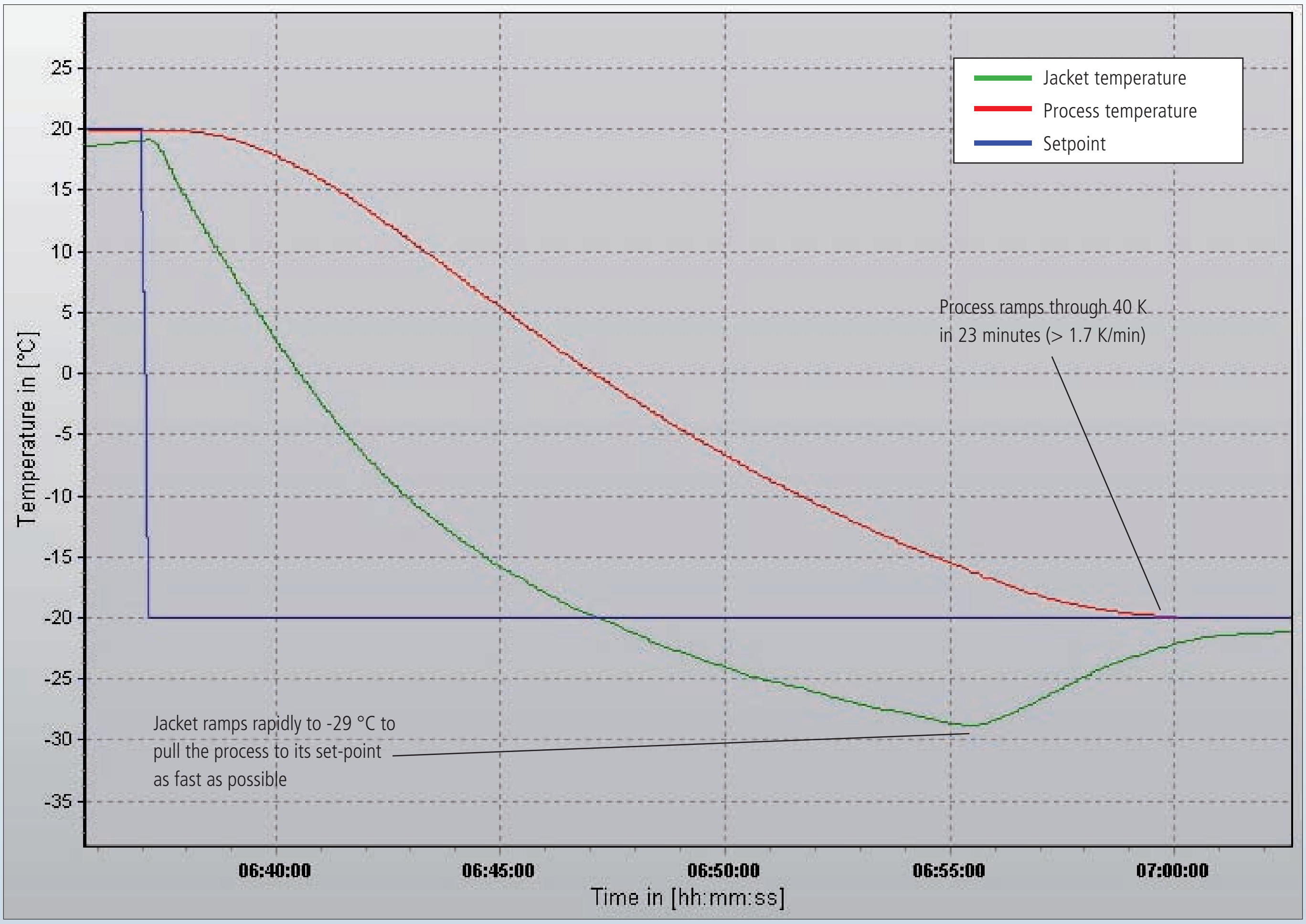
Requirement
This case study looks at the performance of a Unistat® 405w cooling a 2-litre glass reactor from 20 °C to -20 °C (40 K) under "process" control.

Method
The Unistat® 405w was connected to the reactor using two 1-metre insulated metal hoses. The reactor was filled with 1.5 litre of "M90.055.03", a silicon based HTF.

Results
The ramp rate over the temperature change is almost linear at an average speed > 1.7 K / min taking 23 minutes to reach -20 °C.

Setup details
Unistat® 405w & DDPS reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 250…0 °C 0.7 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor contents:	1.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	115 rpm
Control:	process



Setup details
Unistat® 405w & 1-litre vacuum insulated Asahi reactor

Temperature range:	-45...250 °C
Cooling power:	1.3 kW @ 250…0 °C 0.7 kW @ -20 °C
Heating power:	1.5 kW/3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre jacketed glass reactor
Reactor contents:	0.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process

Unistat® 405w

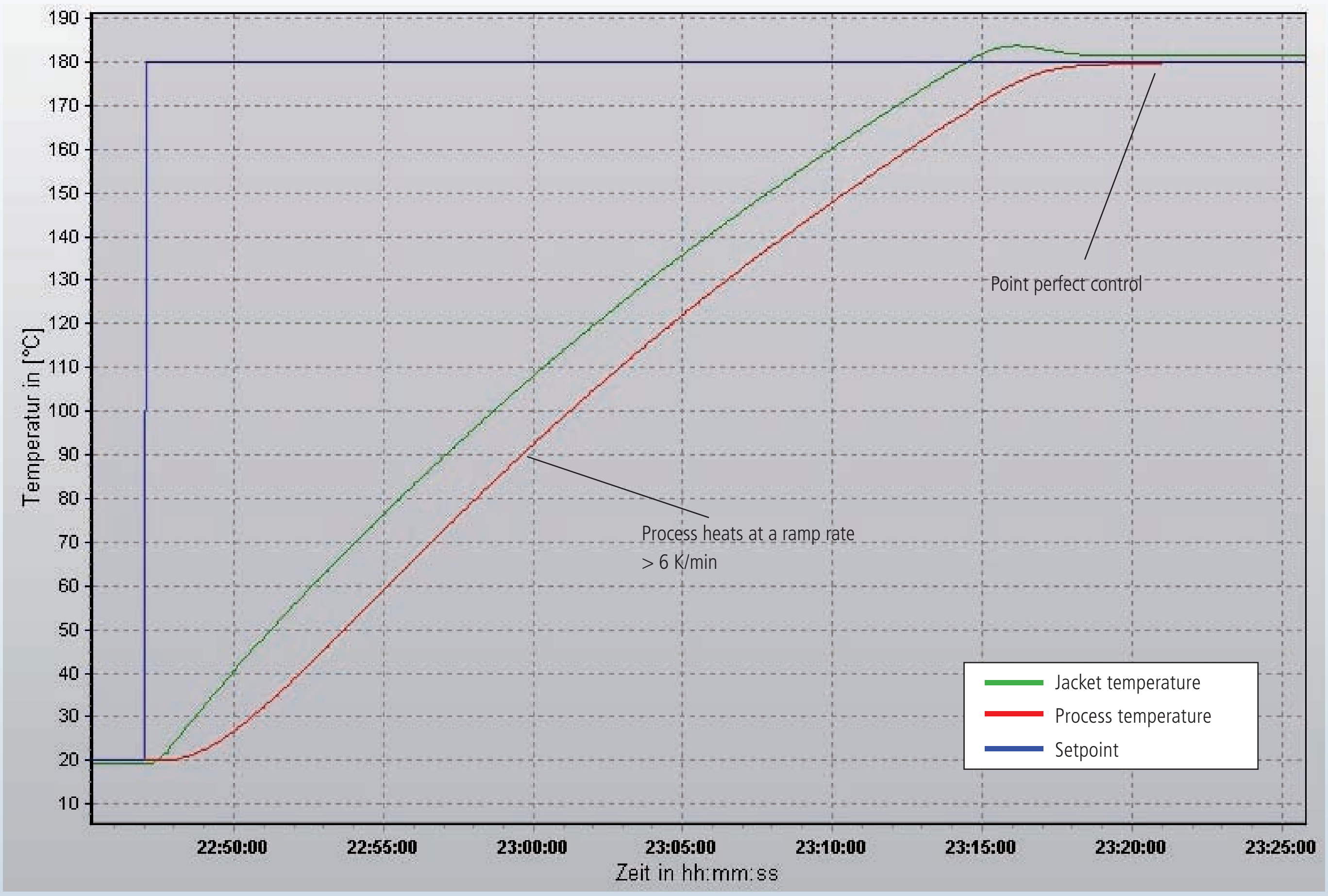
1-litre vacuum insulated Asahi reactor

Requirement
This case study looks at the performance of a Unistat® 405w when connected to an Asahi 1-litre vacuum insulated glass reactor and compares the performance to a reactor with no insulation.

Method
The Unistat® 405w is connected to the reactor using two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a silicon based HTF. The Unistat® 405w was connected in its 3-phase option increasing the available heating power from 1.5 kW to 3 kW.

Results
The set-point is changed from 20 °C to 180 °C. The jacket temperature rapidly ramps bringing the process temperature exactly to 180 °C in 29 minutes.

Unistat® 405w – Asahi reactor insulated:
This graphic shows the performace of Unistat® 405w working with an insulated 1-litre glass reactor. It takes 29 minutes to reach 180 °C from 20 °C.



Version: 9/2009

Unistat®
Tango Nuevo wl

1-litre Radleys reactor

Requirement
This case study compares the heat up ramp of an un-insulated reactor over the same range as the previous case study which used a vacuum insulated 1-litre reactor.

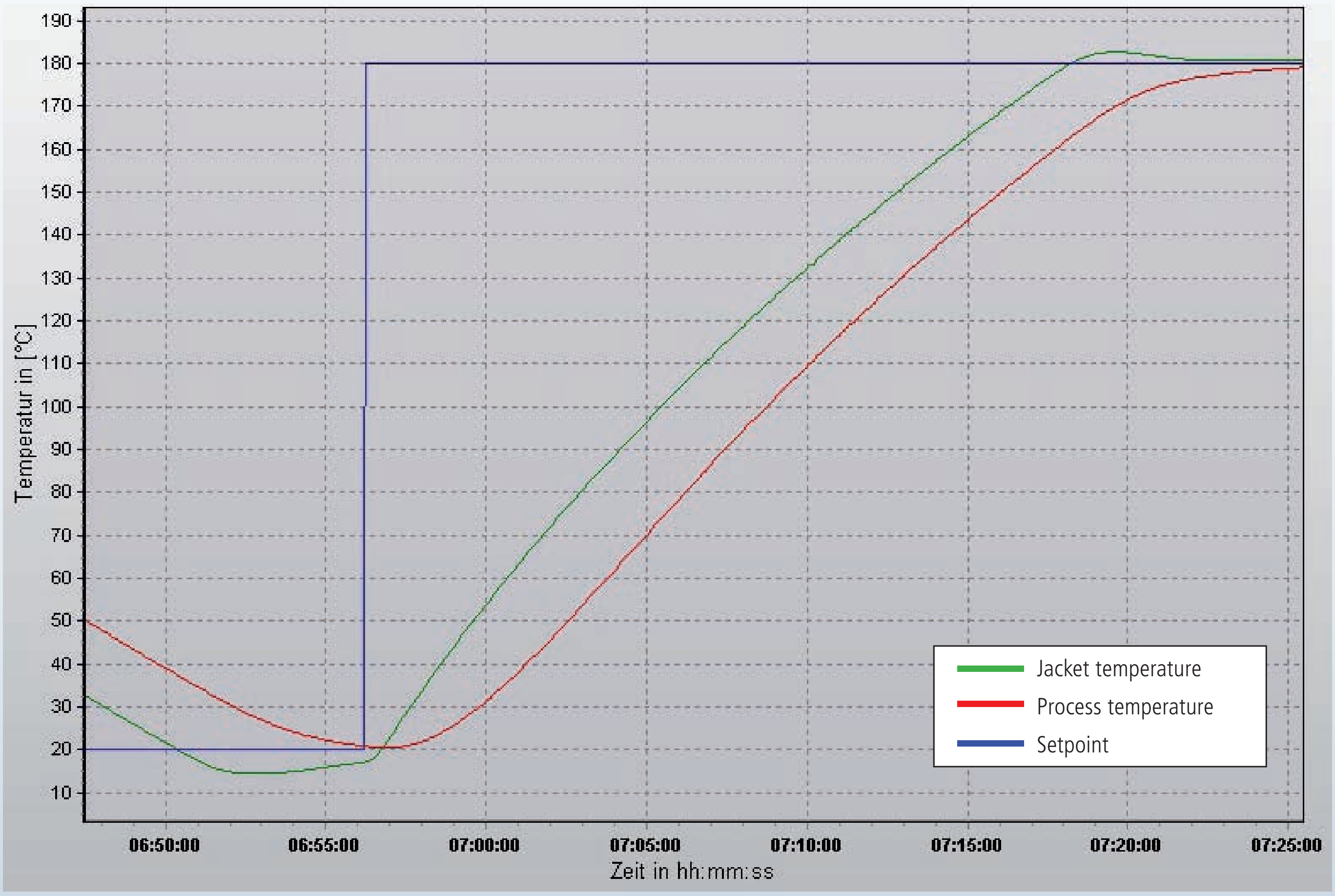
Method
The Unistat® 405w is connected to the reactor using two 1-litre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a silicon based HTF. The Unistat® 405w was connected in its 3-phase option increasing the available heating power from 1.5 kW to 3 kW.

Results
This graphic shows the performance of a Unistat® Tango Nuevo. In this case the temperature range is the same but the glass reactor is not insulated.
Insulated, the reactor heats to 180 °C from 20 °C in only 29 minutes to reach the required temperature as compared to 32 minutes when the reactor is un-insulated.

Setup details
Unistat® Tango Nuevo wl & Radleys reactor

Temperature range:	-45...250 °C
Cooling power:	0.7 kW @ 250…0 °C 0.4 kW @ -20 °C
Heating power:	1.5 kW / 3 kW
Pump speed	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre jacketed glass reactor
Reactor contents:	0.75 litre M90.055.03 (#6259) Specific heat capacity of 0.36 kcal / kg °C
Reactor stirrer speed:	200 rpm

Unistat® Tango Nuevo – Radleys reactor un-insulated:
This graphic shows the performance of Unistat® Tango Nuevo working with an un-insulated 1-litre glass reactor. It takes 35 minutes to reach 180 °C from 20 °C.



Version: 9/2009

Unistat® 425

Controlling a simulated 100 W (86 kcal / hr) exothermic reaction

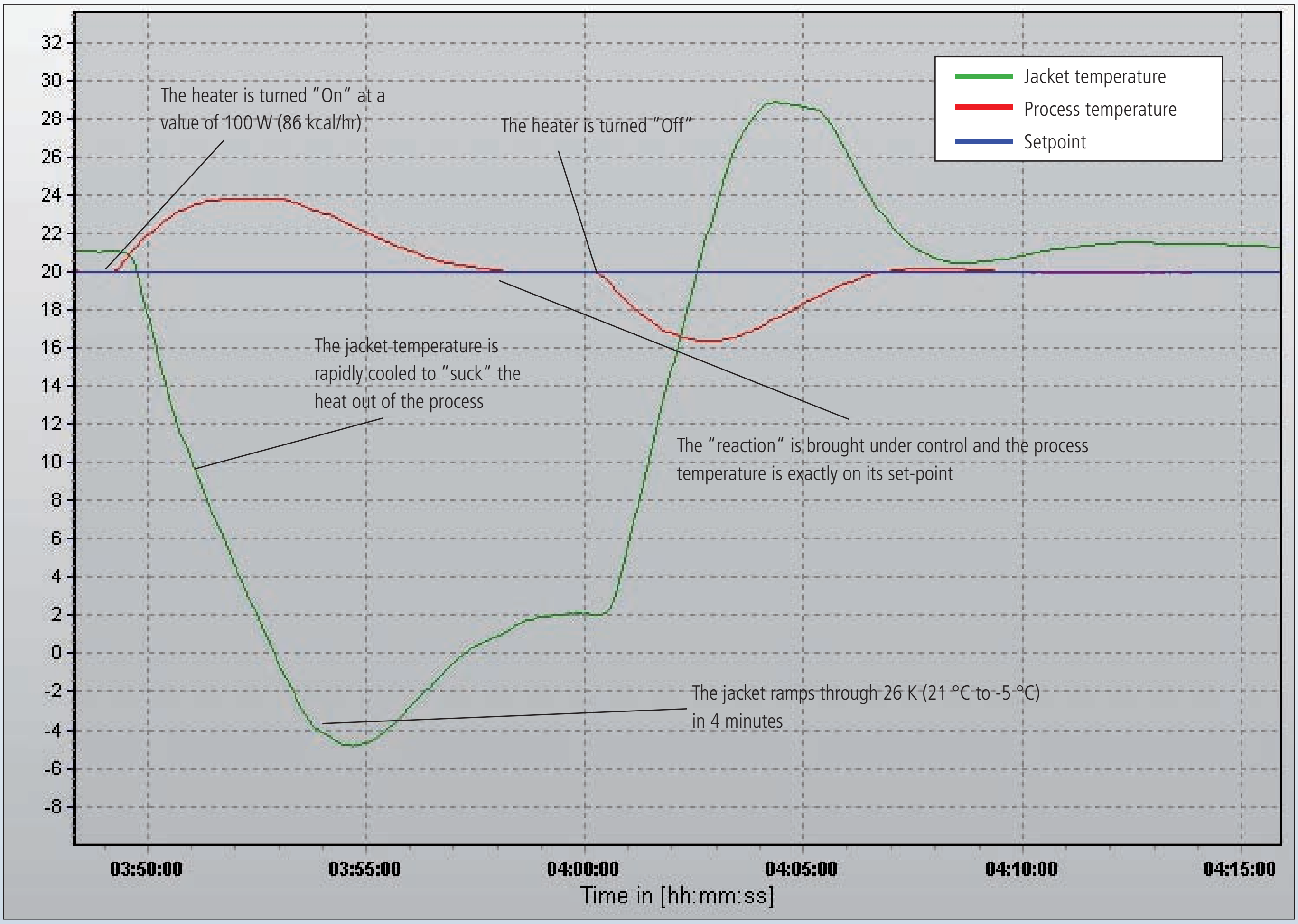
Requirement
This case study looks at the performance of a Unistat® 425 as it controls a simulated 100 W (86 kcal / hr) exothermic reaction in a 2-litre DDPS reactor.

Method
The Unistat® 425 is connected to the 2-litre DDPS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 1.5 litre of "M90.055.03", a silicon based HTF. An electric heater is immersed in the "process" and controlled to give a pre-determined power value.

Results
As soon as the "reaction" starts and raises the temperature of the process the Unistat® cools the jacket to generate a wide ΔT rapidly to remove the heat and bring the process temperature back to its set-point. The reaction is caught and controlled within 7 minutes. The heater is then turned off and the Unistat® responds again by ramping the jacket to return and hold the process at its set-point

Setup details
Unistat® 425 & DDPS 2-litre reactor

Temperature range:	-40...250 °C
Cooling power:	2.5 kW @ 0 °C 1.8 kW @ -20 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	150 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 425 & DDPS reactor

Temperature range:	-40...250 °C
Cooling power:	2.5 kW @ 0 °C 1.8 kW @ -20 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor contents:	1.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	150 rpm
Control:	internal

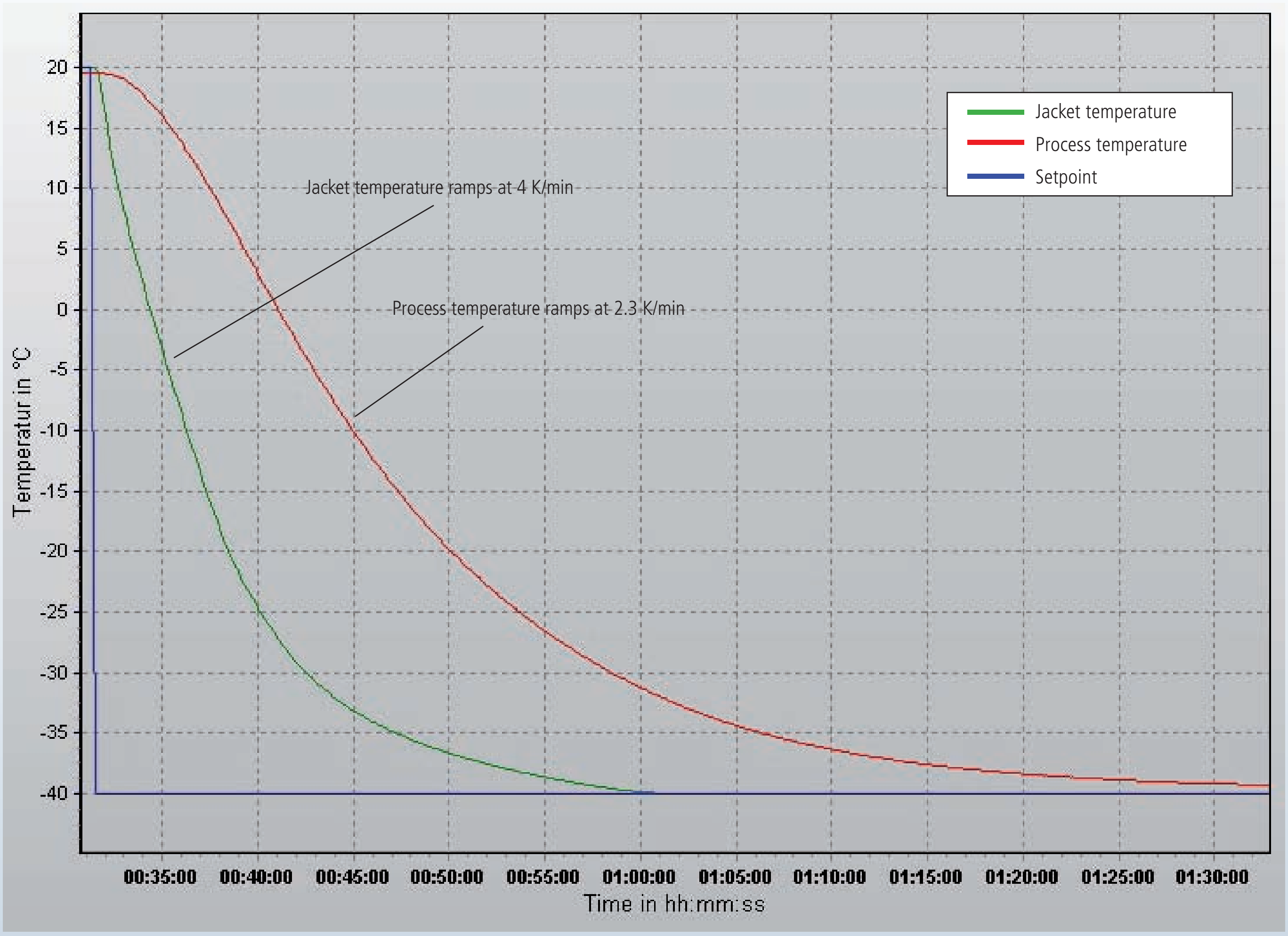
Unistat® 425

Cooling a DDPS 2-litre jacketed glass reactor to T_{min}

Requirement
This case study is to find out the minimum temperature that a Unistat® 425 can cool the jacket of a 2-litre jacketed glass reactor and the resultant process temperature.

Method
The Unistat® 425 is connected to the 2-litre DDPS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 1.5 litre of "M90.055.03", a silicon based HTF

Results
The jacket is cooled to -40 °C in around 33 minutes. The process temperature ramp rate slows as the ΔT narrows and has reached -39 °C when the test is stopped.



Version: 9/2009

Unistat® 425

Cooling a DDPS 2-litre jacketed glass reactor from 20 °C to -20 °C

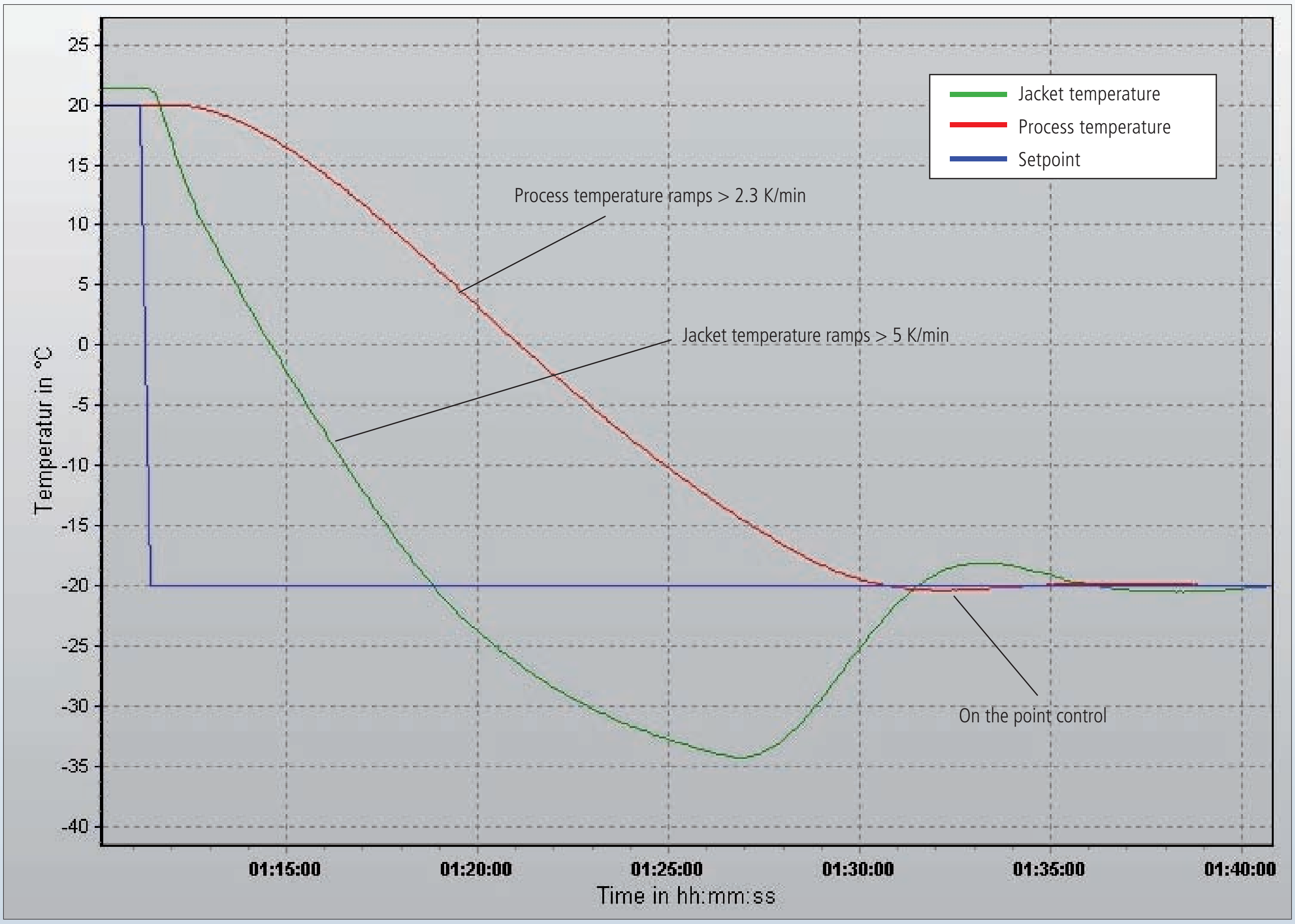
Requirement
This case study looks at the performance of a Unistat® 425 as it cools a jacketed glass reactor from 20 °C to -20 °C.

Method
The Unistat® 425 is connected to the 2-litre DDPS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 1.5 litre of "M90.055.03", a silicon based HTF.

Results
It can be seen that the process is ramped through 40 K (20 °C to -20 °C) within 20 minutes.

Setup details
Unistat® 425 & DDPS reactor

Temperature range:	-40...250 °C
Cooling power:	2.5 kW @ 0 °C 1.8 kW @ -20 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	150 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 425 & DDPS reactor

Temperature range:	-40...250 °C
Cooling power:	2.5 kW @ 0 °C 1.8 kW @ -20 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	150 rpm
Control:	process

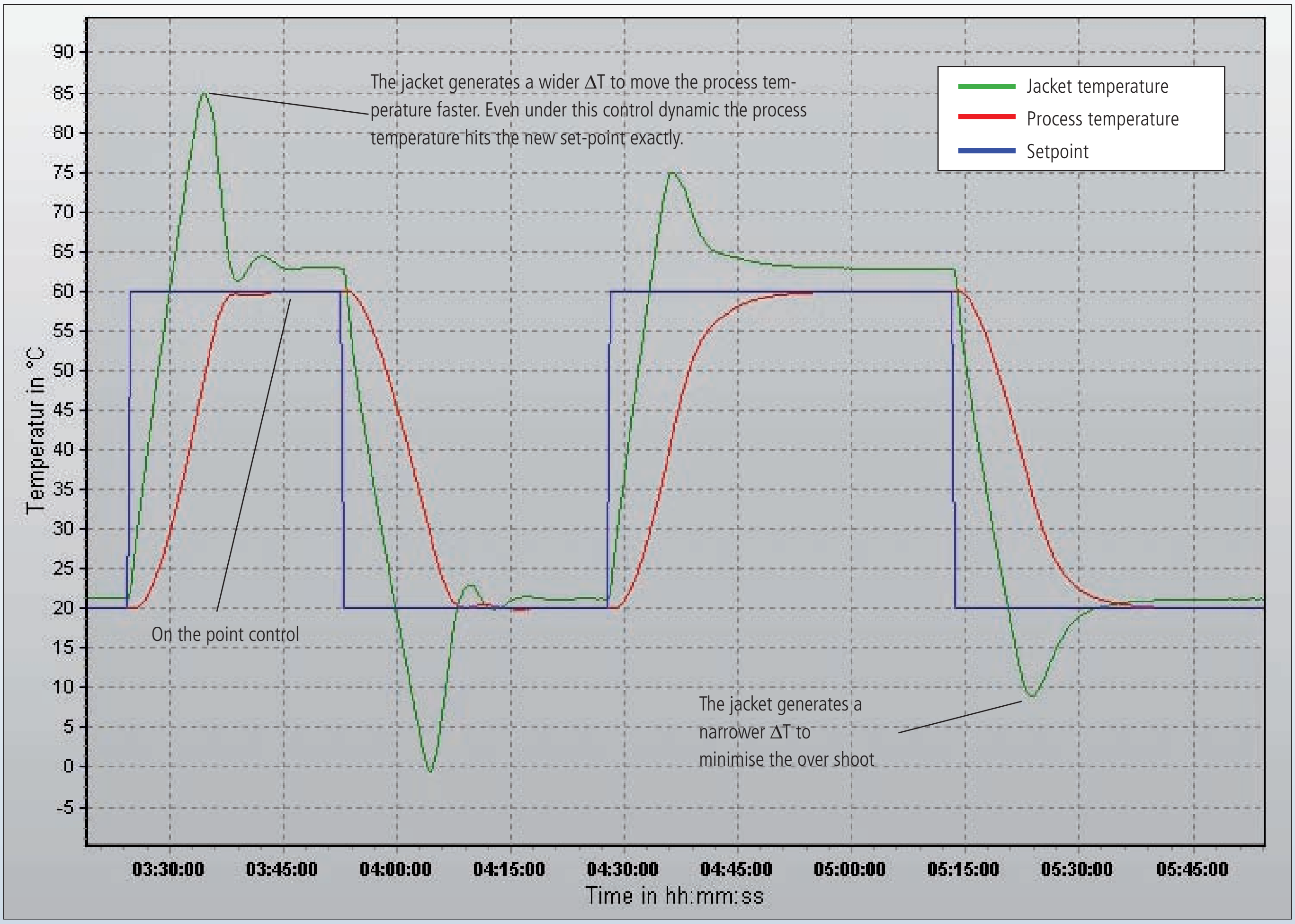
Unistat® 425

Heating and cooling a 2-litre jacketed glass pressure reactor under differing control dynamics

Requirement
A standard feature of the "Pilot Controller" is to choose "fast, small overshoot" or "without overshoot" when reaching a set-point.
The graphic shows the differences in performance between these settings. In this test the Unistat® 425 is programmed to alternate between 20 °C and 60 °C.

Method
The Unistat® 425 is connected to the 2-litre DDPS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 1.5 litre of "M90.055.03", a silicon based HTF.

Results
The first process curve (fast, small overshoot) reaches 60 °C in just 14 minutes with the second process curve (without overshoot) takes 24 minutes to reach the set-point.
It can be seen that the overshoot is minimal in the "fast, small overshoot" mode.



Version: 9/2009

Unistat® 425

Heating and cooling a 2-litre glass reactor between 20 °C & 100 °C

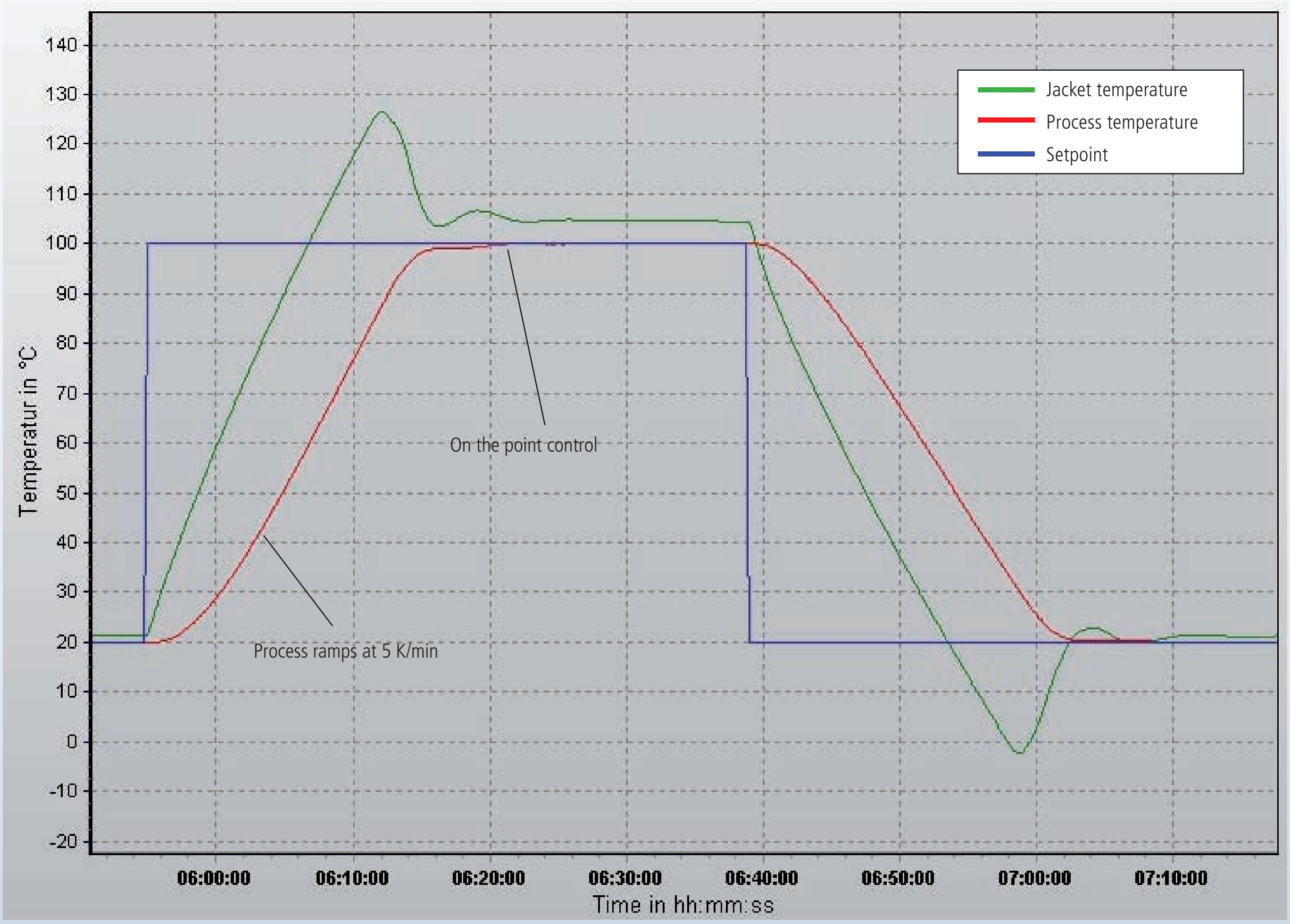
Requirement
This case study looks at the performance of a Unistat® 425 as it heats and cools a jacketed glass reactor between 20 °C and 100 °C.

Method
The Unistat® 425 is connected to the 2-litre DDPS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 1.5 litre of "M90.055.03", a silicon based HTF.

Results
It can be seen that the process is ramped through 80 K (20 °C to 100 °C) within 20 minutes. To cool the process back to 20 °C takes approximately 23 minutes.

Setup details
Unistat® 425 & DDPS reactor

Temperature range:	-40...250 °C
Cooling power:	2.5 kW @ 0 °C 1.8 kW @ -20 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	150 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 425w & HWS reactor

Temperature range:	-40...250 °C
Cooling power:	Heating power:
2.0 kW	
Hoses:	2x1 m M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process

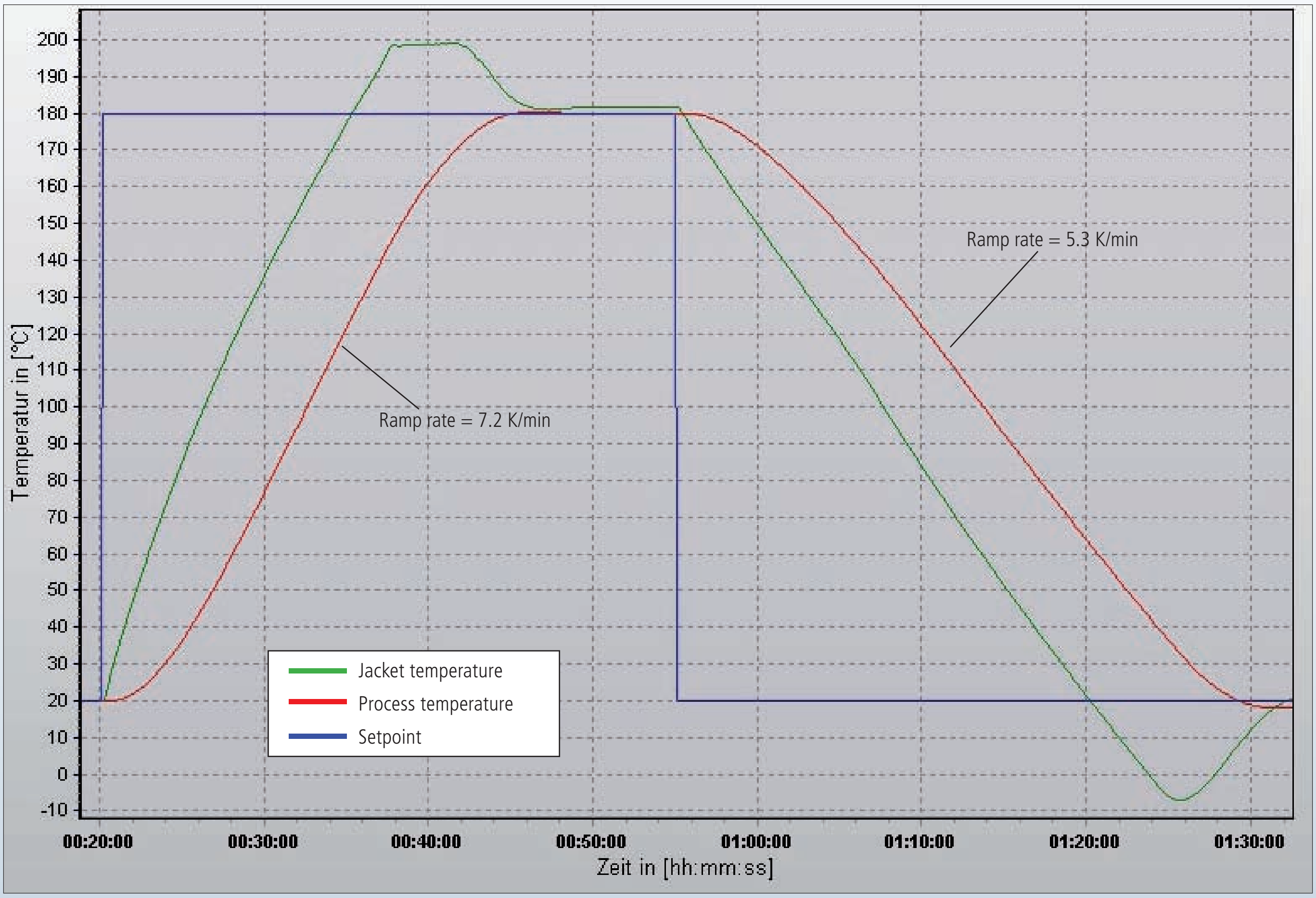
Unistat® 425w

Heating and cooling a HWS 5-litre glass reactor between 20 °C & 180 °C

Requirement
This case study looks at the speed of response when a set-point change is made from 20 °C to 180 °C when a Unistat® 425w is connected with a HWS 5-litre jacketed glass reactor.

Method
The Unistat® 425w is connected to the 5-litre HWS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 3.75 litre of "M90.055.03", a silicon based HTF.

Results
It takes 22 minutes to heat from 20 °C to 180 °C achieving heating ramp rate of approx. 7.2 K / min. The process temperature experiences no overshoot above the set-point (180 °C).
In this test the „internal" (jacket) temperature is limited so as not to exceed the max. set-point which is set at 200 °C.
The cool-down time of the process is 33 minutes from 180 °C to 20 °C giving a ramp rate of 5.3 K / min.



Unistat® 425w

HWS 5-litre reactor

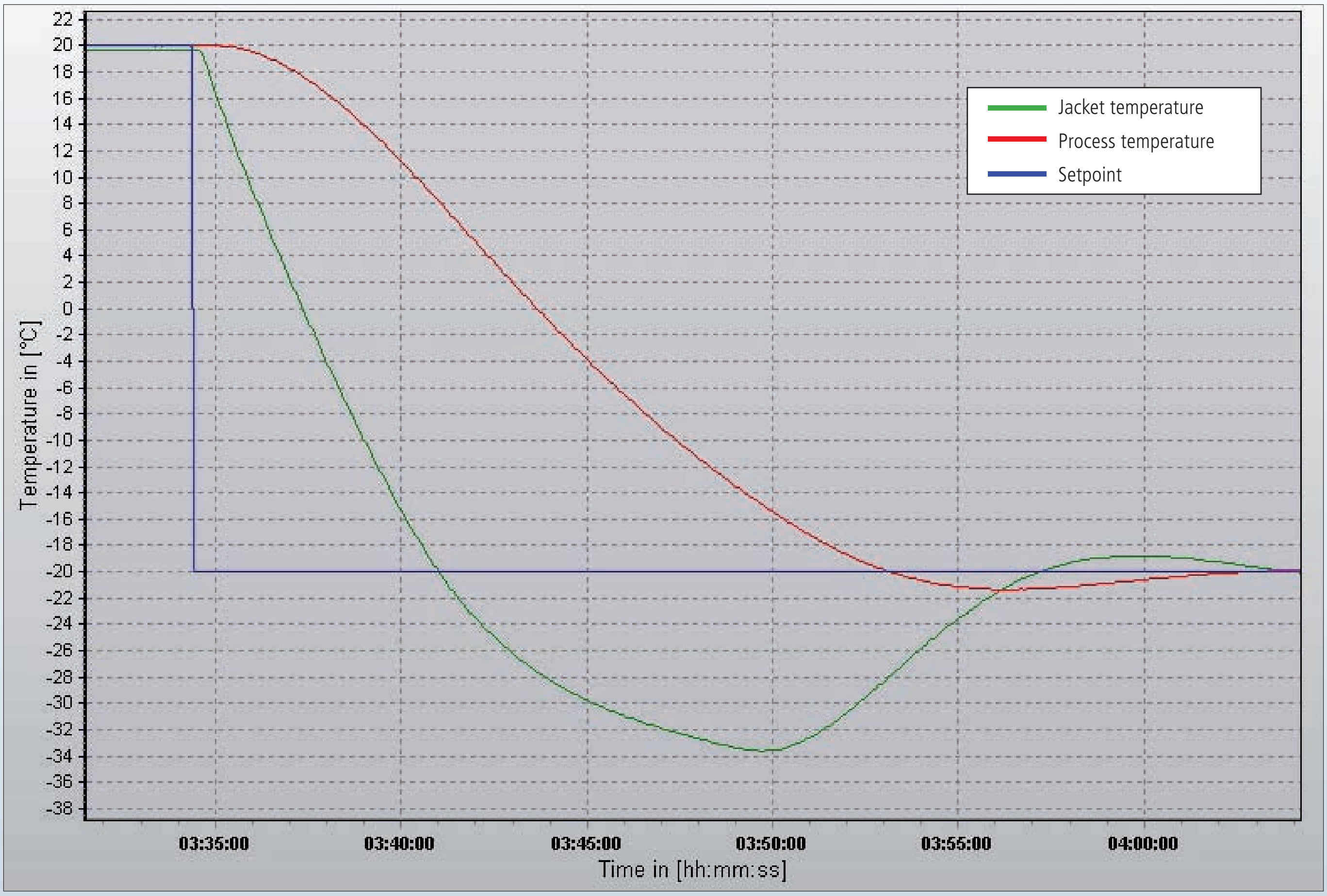
Requirement
This case study looks at the speed of response when a set-point change from 20 °C to -20 °C when a Unistat® 425w is connected to a HWS 5-litre reactor.

Method
The Unistat® 425w is connected to the 5-litre HWS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 3.75 litre of "M90.055.03", a silicon based HTF.

Results
It takes 19 minutes for the process temperature to reach its set-of -20 °C, i.e. a cooling rate of 2.1 K / min.
It can be seen how the internal temperature ramps rapidly to almost -34 °C, thus the process temperature can reach the set-point as soon as possible.

Setup details
Unistat® 425w & HWS 5-litre reactor

Temperature range:	-40...250 °C
Cooling power:	2.8 kW @ 250...100 °C 2.5 kW @ 0 °C 1.9 kW @ -20 °C 0.2 kW @ -40 °C
Heating power:	2.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 425w & HWS reactor

Temperature range:	-40...250 °C
Cooling power:	2.8 kW @ 250...100 °C 2.5 kW @ 0 °C 1.9 kW @ -20 °C 0.2 kW @ -40 °C
Heating power:	2.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor content:	3.75 litre M90.055.03 (#6259)
Stirrer:	200 rpm
Control:	process

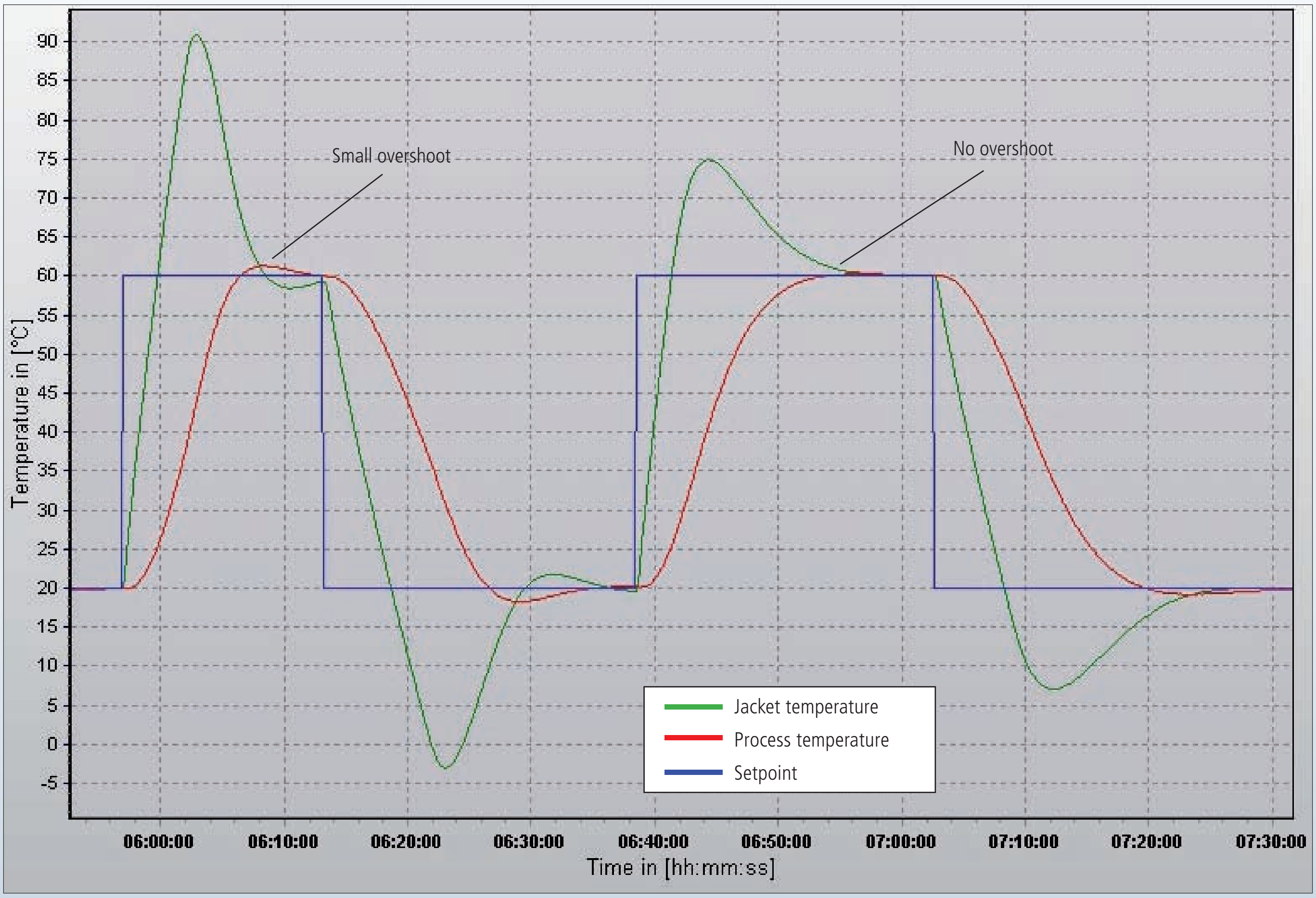
Unistat® 425w

Periodic and Aperiodic control on a 5-litre HWS reactor

Requirement
The "Unistat® Pilot" offers the possibility of using either periodic or aperiodic control settings. That means the set-point temperature can be achieved with or without an overshoot.
The graphic shows the performance curve of a Unistat® 425w working with a HWS 5-litre glass reactor as it heat and cools between 20 °C and 60 °C under different control dynamics.

Method
The Unistat® 425w is connected to the 5-litre HWS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 3.75 litre of "M90.055.03", a silicon based HTF.

Results
The first process curve (with overshoot) goes from 20 °C to 60 °C in just 10 minutes and the second curve (without overshoot) working with the same temperature range takes 15 minutes.



Version: 9/2009

Unistat® 425w

Cooling a 5-litre HWS reactor

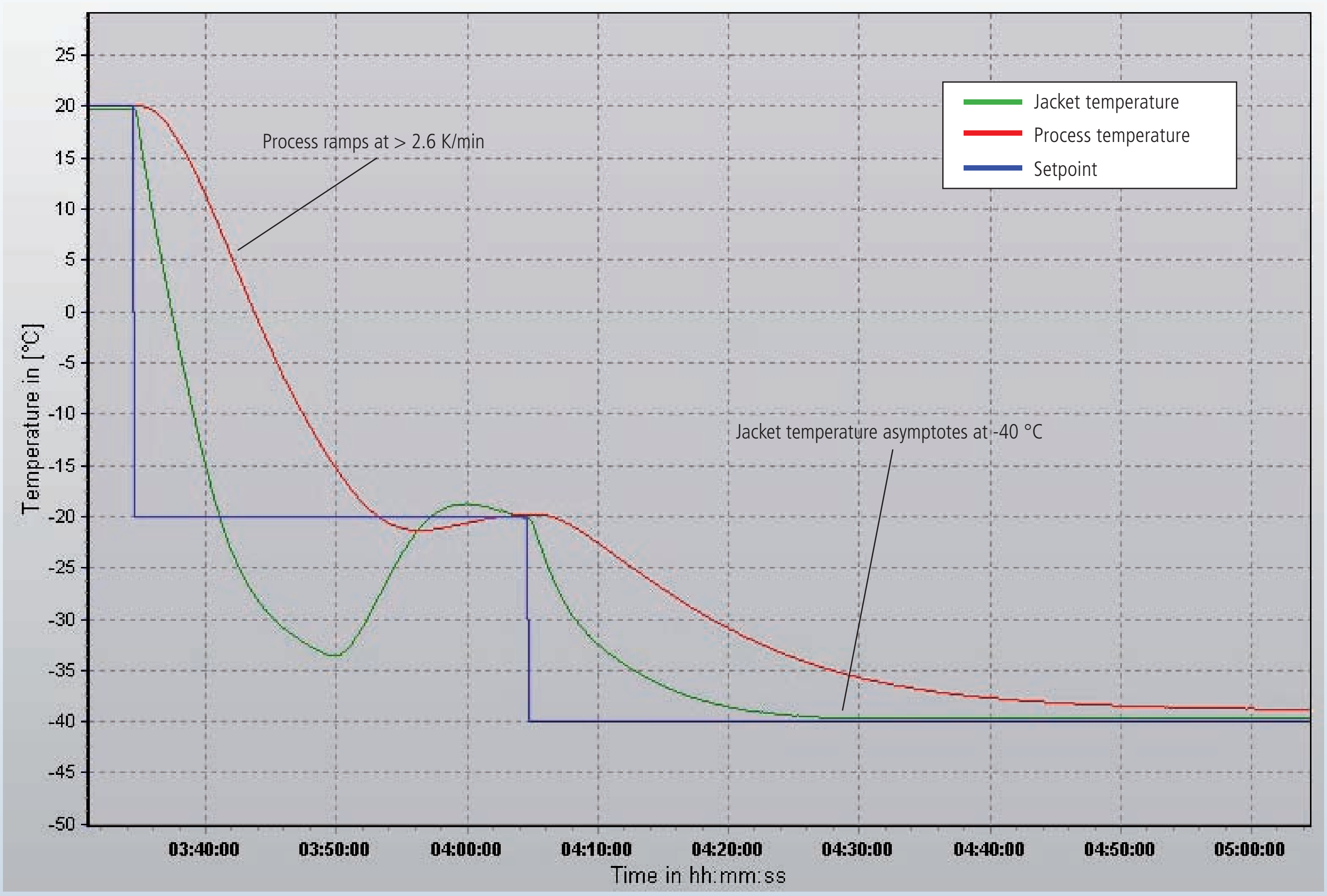
Requirement
This case study looks at the performance of a Unistat® 425w cooling a 5-litre glass reactor from 20 °C to -20 °C and then to T_{min} under "process" control.

Method
The Unistat® 425w is connected to the 5-litre HWS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 3.75 litre of "M90.055.03", a silicon based HTF.

Results
The jacket cools quickly to -33 °C to pull the process to its new set-point from 20 °C to -20 °C (40 K) within 15 minutes (ramp rate > 2.6 K / min).
Once temperatures are stable a set-point of -40 °C is entered. After approximately 22 minutes the jacket temperature asymptotes at -40 °C with a corresponding end-process temperature of -39 °C.

Setup details
Unistat® 425w & 5-litre HWS reactor

Temperature range:	-40...250 °C
Cooling power:	2.8 kW @ 250...100 °C
	2.5 kW @ 0 °C
	1.9 kW @ -20 °C
	0.2 kW @ -40 °C
Heating power:	2.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Unistat® 425w

Heating a HWS 5-litre jacketed glass reactor from 20 °C to 100 °C

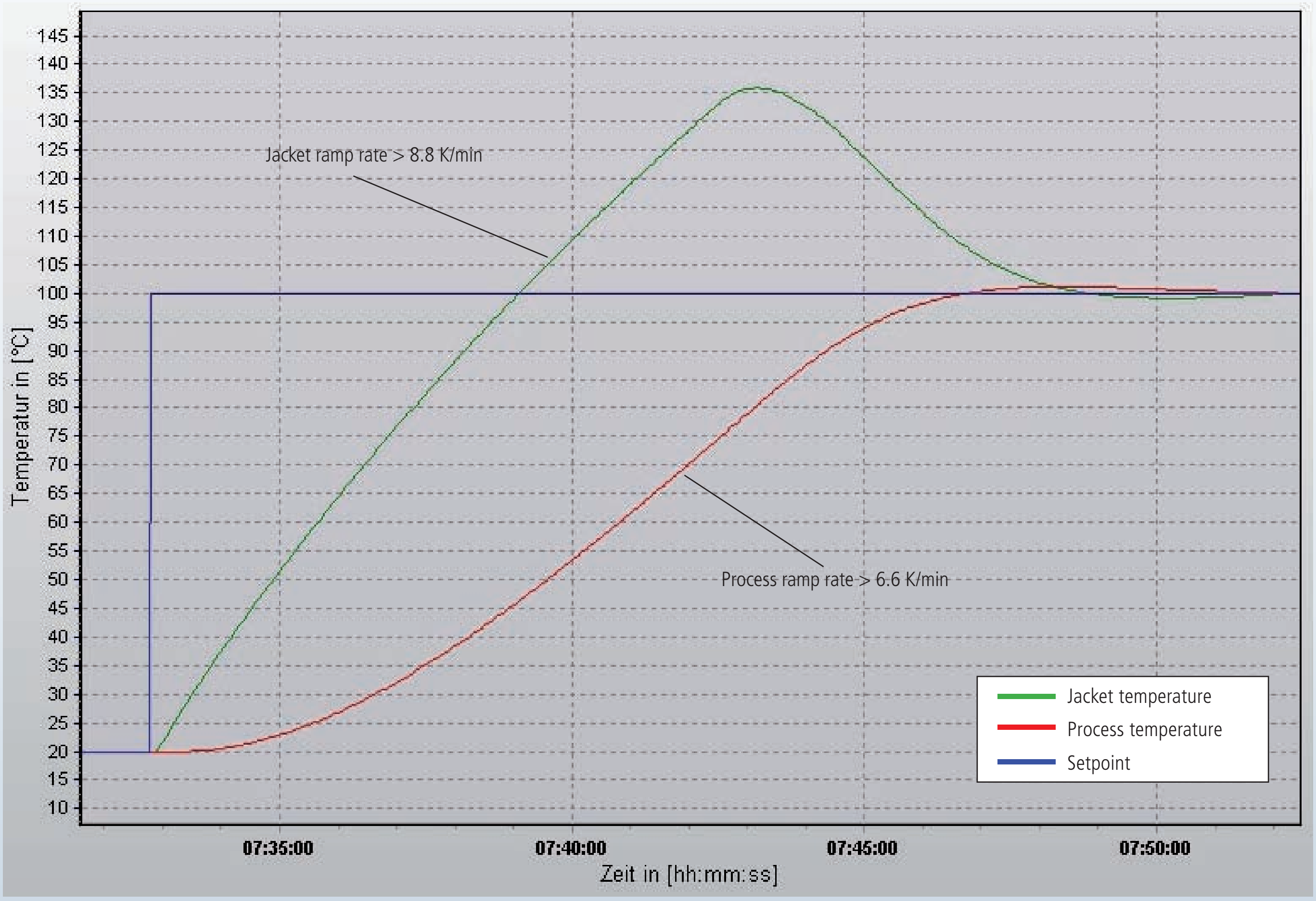
Requirement
This case study looks at the performance of a Unistat® 425w heating a 5-litre glass reactor from 20 °C to 100 °C under "process" control.

Method
The Unistat® 425w is connected to the 5-litre HWS glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 3.75 litre of "M90.055.03", a silicon based HTF´.

Results
The jacket heats from 20 °C to 135 °C within 10 minutes (ramp rate > 8.8 K / min) pulling the process temperature to its 100 °C set-point within 12 minutes (ramp rate > 6.6 K / min).

Setup details
Unistat® 425w & HWS reactor

Temperature range:	-40...250 °C
Cooling power:	2.8 kW @ 250...100 °C 2.5 kW @ 0 °C 1.9 kW @ -20 °C 0.2 kW @ -40 °C
Heating power:	2.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Setup details
Unistat® 425w & Büchi reactor
(büchiglasuster)

Temperature range:	-40...250 °C
Cooling power:	2.8 kW @ 250...100 °C 2.5 kW @ 0 °C 1.9 kW @ -20 °C 0.2 kW @ -40 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content:	15 litre M90.055.03 (#6259)
Stirrer:	150 rpm
Control:	process

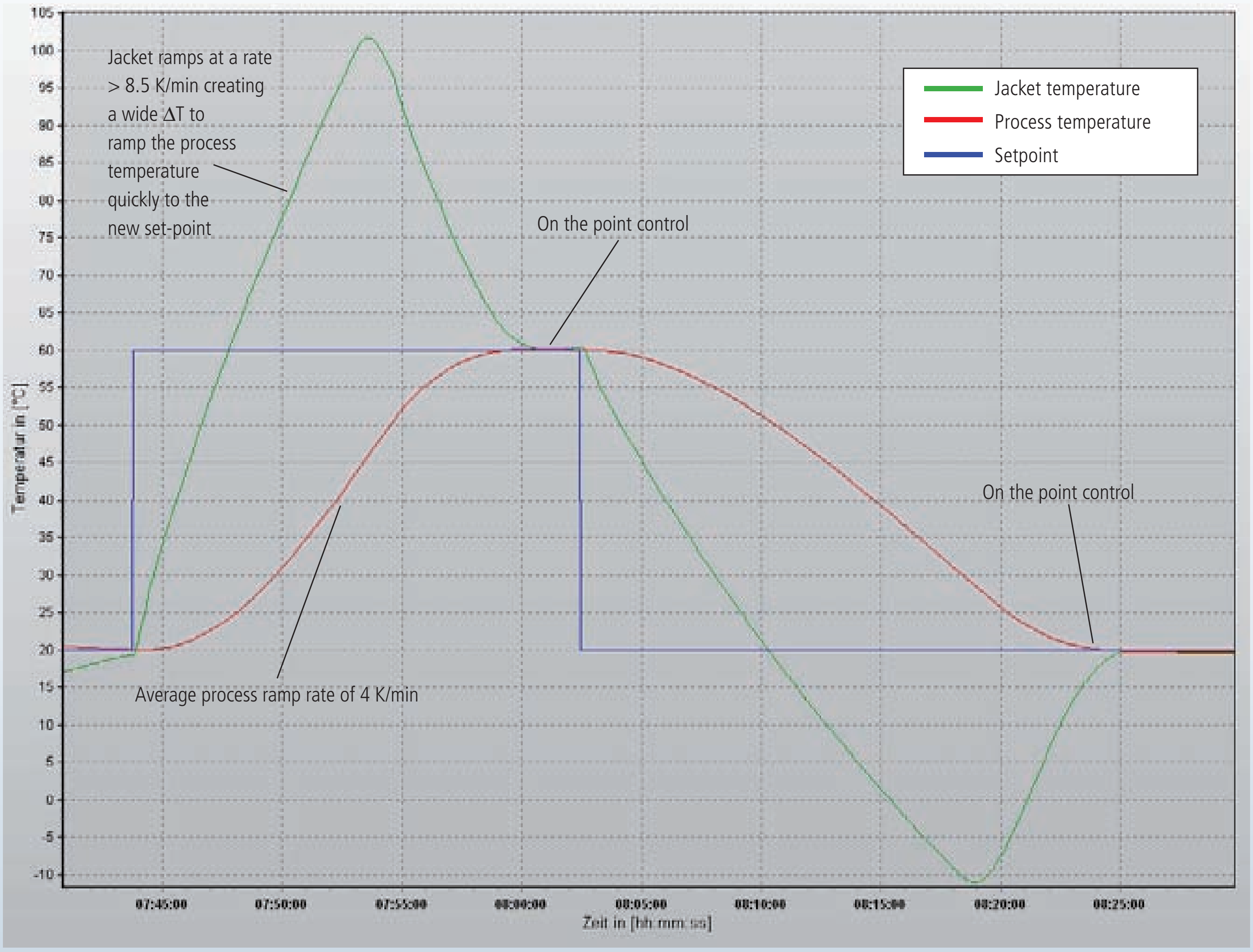
Unistat® 425w

Heating a Büchi 20 litre jacketed glass reactor to 60 °C

Requirement
This case study looks at the performance of a Unistat® 425w heating a 20-litre glass reactor from 20 °C to 60 °C under "process" control.

Method
The Unistat® 425w is connected to the 20-litre Büchi glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 15 litre of "M90.055.03", a silicon based HTF.

Results
The jacket heats quickly to 102 °C creating a wide ΔT to pull the process temperature to its new set-point. As the process approaches the set-point the jacket cools rapidly to guide the process precisely to target temperature.



Version: 9/2009

Unistat® 425w

Cooling a Büchi 20 litre jacketed glass reactor

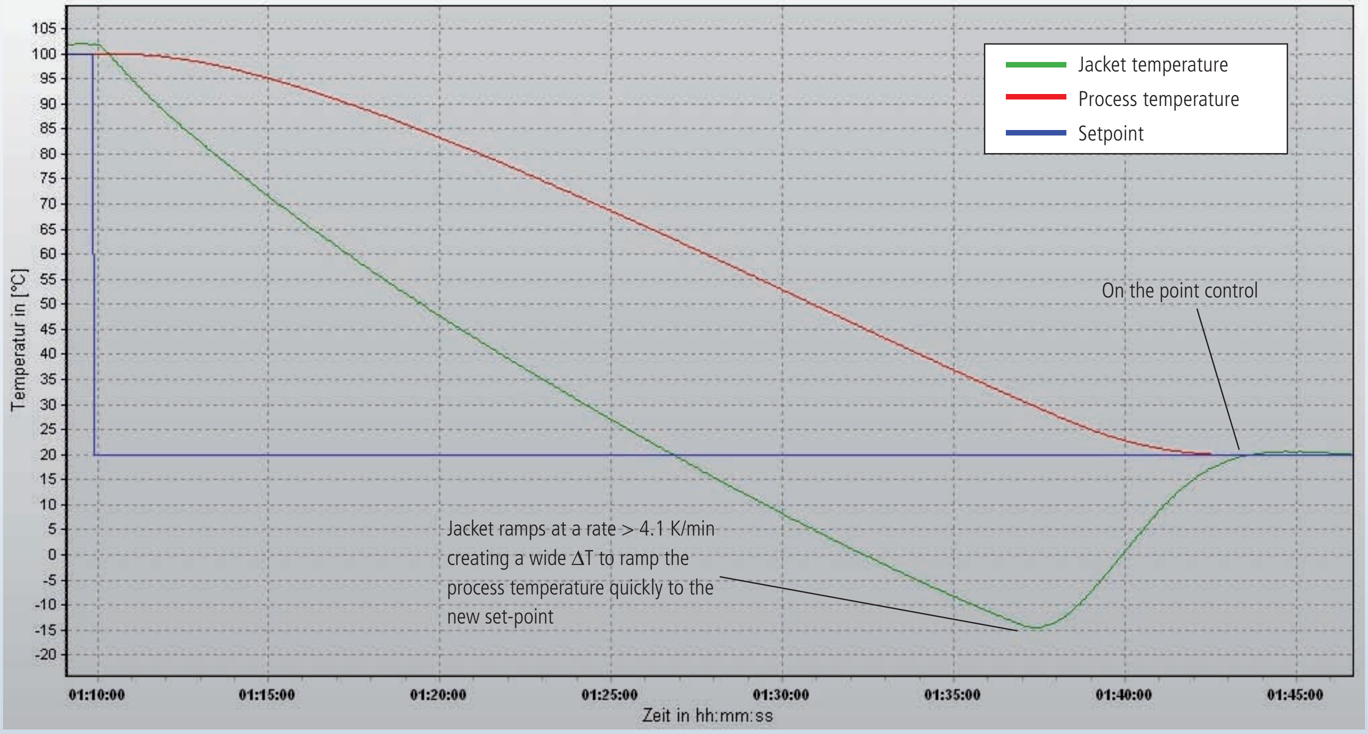
Requirement
This case study looks at the performance of a Unistat® 425w cooling a Büchi 20-litre glass reactor from 100 °C to 20 °C under "process" control.

Method
The Unistat® 425w is connected to the 20-litre Büchi glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 15 litre of "M90.055.03", a silicon based HTF.

Results
The jacket temperature ramps through 115 K (100 °C to -15 °C) within 28 minutes (ramp rate > 4.1 K / min) to pull the process to its new set-point. As the process approaches target temperature the jacket heats to guide the process precisely to its target temperature.

Setup details
Unistat® 425w & Büchi reactor (büchiglasuster)

Temperature range:	-40...250 °C
Cooling power:	2.8 kW @ 250...100 °C 2.5 kW @ 0 °C 1.9 kW @ -20 °C 0.2 kW @ -40 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre un-insulated glass reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	150 rpm
Control:	process



Setup details
Unistat® 425w & Büchi reactor
(büchiglasuster)

Temperature range:	-40...250 °C
Cooling power:	2.8 kW @ 250...100 °C 2.5 kW @ 0 °C 1.9 kW @ -20 °C 0.2 kW @ -40 °C
Heating power:	2.0 kW
Hoses:	2x1 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content:	15 litre M90.055.03 (#6259)
Stirrer:	150 rpm
Control:	process

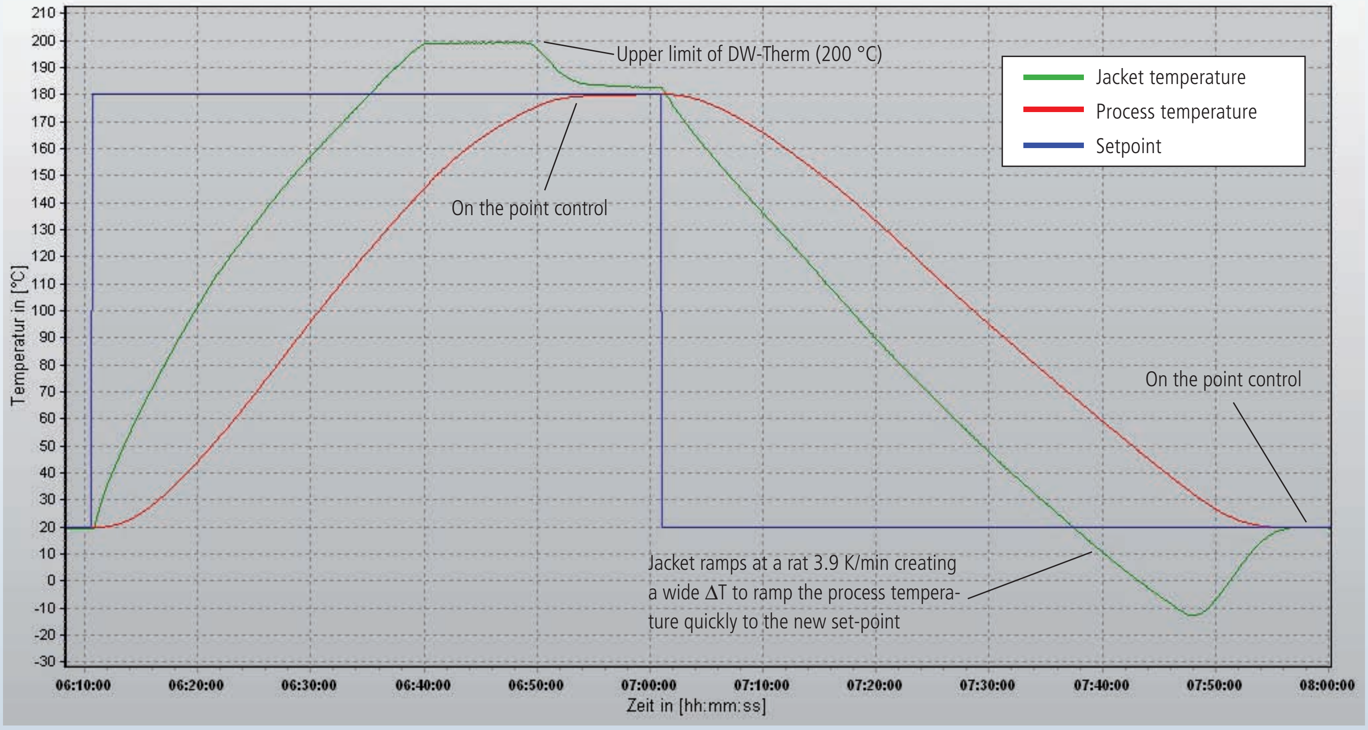
Unistat® 425w

Heating & cooling a 20 litre Büchi jacketed glass reactor

Requirement
This case study looks at the performance of a Unistat® 425w heating and cooling a 20-litre Büchi glass reactor from 20 °C to 180 °C and back to 20 °C under "process" control.

Method
The Unistat® 425w is connected to the 20-litre Büchi glass reactor using two insulated metal 1-metre hoses. The reactor is filled with 15 litre of "M90.055.03", a silicon based HTF.

Results
The jacket temperature ramps through 180 K (20 °C to 200 °C) within 30 minutes (ramp rate 6 K / min) to pull the process to its new set-point. As the process approaches target temperature the jacket cools to guide the process precisely to its target temperature.
The cooling cycle shows a similar performance with the jacket cooling rapidly to -13 °C from 182 °C (195 K) within 50 minutes (ramp rate 3.9 K / min) to pull the process back to 20 °C as quickly as possible.



Version: 9/2009

Setup details
Unistat® 510w & DDPS reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250…0 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated jacketed glass reactor
Reactor content:	18.75 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	internal

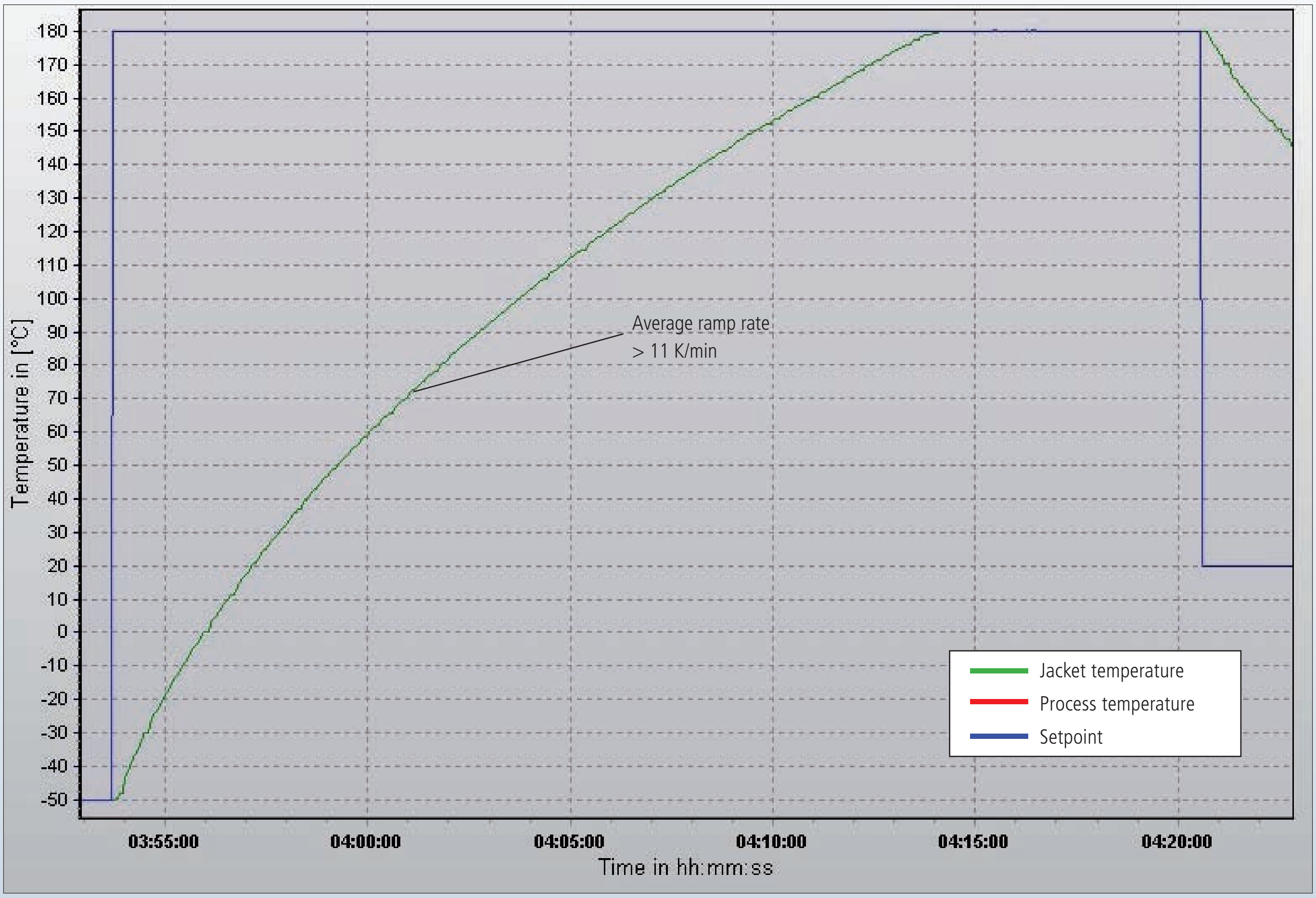
Unistat® 510w

Heating a 25 litre DDPS reactor

Requirement
The graphic shows the performance of a Unistat® 510w working with a 25-litre glass reactor connected together with M38x1.5 hoses.

Method
The DDPS 25-litre reactor and Unistat® 425w were connected together with insulated "M38x1.5" hoses. The HTF circuit (reactor, Unistat® & hoses) was filled with DW-Therm and the reactor was filled with 18.75 litre of "M90.055.03", a silicon based Huber supplied HTF.

Results
The "internal" (jacket) temperature increases at a rate > 11 K per minute and reaches the set-point of 180 °C from -50 °C without any overshoot or undershoot within 21 minutes.



Version: 9/2009

Unistat® 510w

Controlling a simulated 300 W (258 kcal / hr) exothermic reaction in a 15 litre Büchi reactor

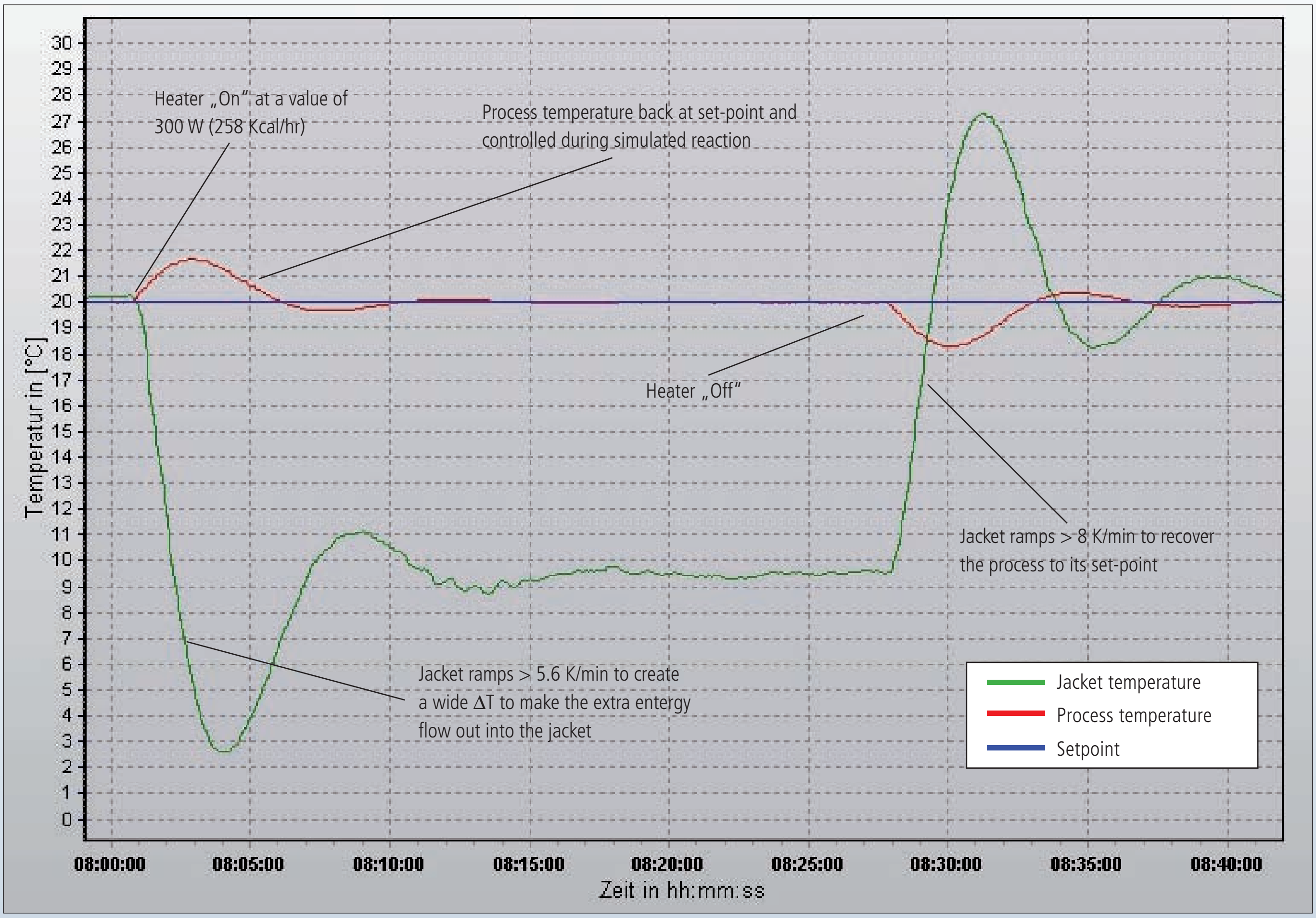
Requirement
This case study shows the temperature profile of a specific test while undergoing a simulated exothermic reaction.

Method
A Unistat® 510w has been selected to control the process temperature inside a 5 litre glass-lined (enameled) steel reactor which is 2/3 filled with M20.235.20.

Results
The 300 W exothermic reaction increases the process temperature by approx. 1.7 K and the Unistat® compensates the temperature difference in 9 minutes. After a while the heater is removed out of the reactor and the process temperature goes down to approx. 18.3 °C. The Unistat® takes 12 minutes to bring back the process temperature to its set-point.

Setup details
Unistat® 510w & Büchi reactor (büchiglasuster)

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 0…250 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	15 litre glass-lined (enameled) steel reactor
Reactor content:	10 litre M20.235.20 (#6162)
Stirrer speed:	80 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 510w & DDPS reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250...0 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	DDPS 25 litre vacuum insulated glass reactor
Reactor content:	18.75 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process

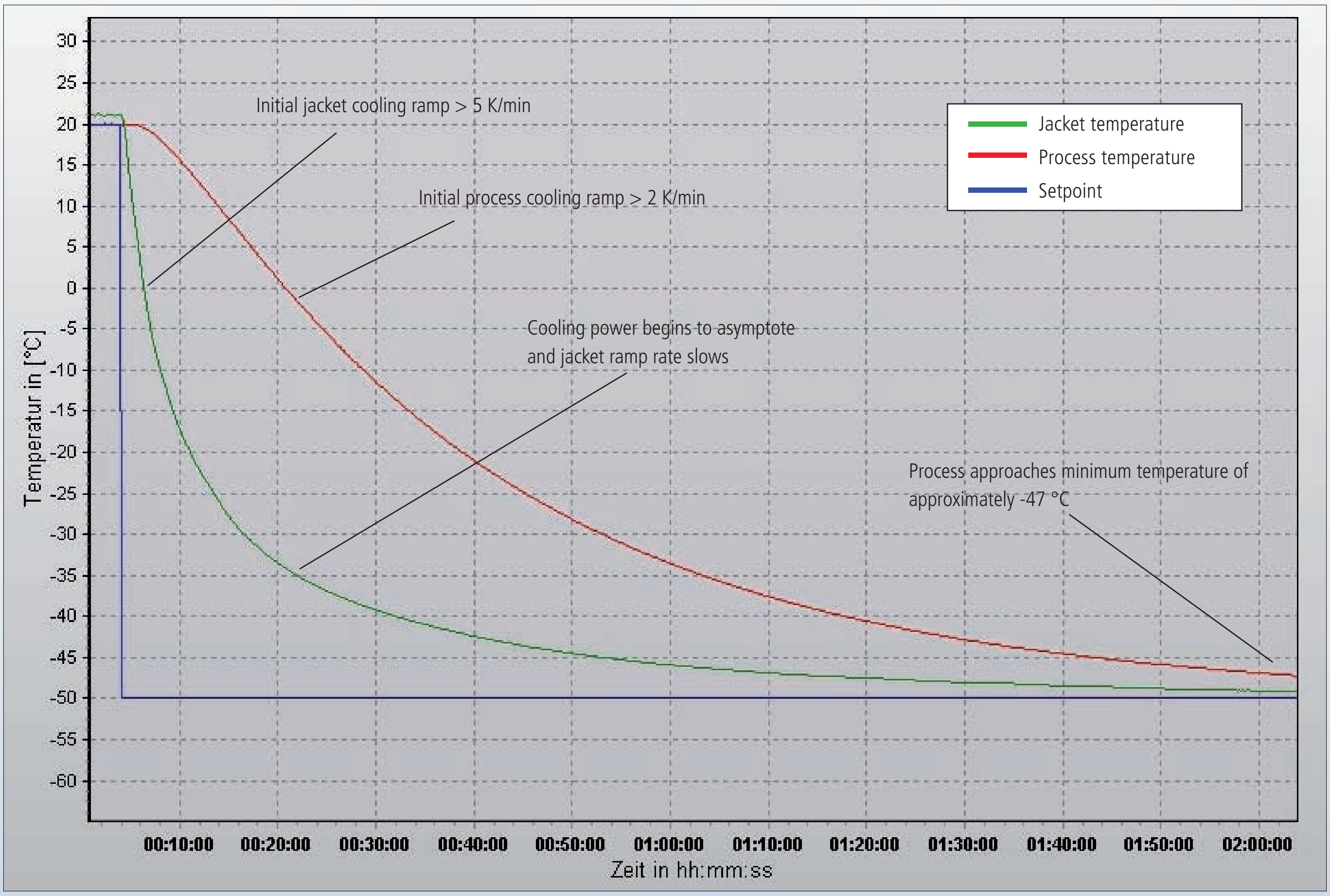
Unistat® 510w

Cooling a 25 litre DDPS reactor to "T_{min}"

Requirement
This case study examines the minimum temperature that a Unistat® 510w can take the process temperature contained in a 25-litre vacuum-insulated glass reactor.

Method
The DDPS reactor was connected to the Unistat® 510w using two 1.5 m insulated metal hoses. The reactor was filled with 18.75 litre of "M90.055.03", a silicon based Huber supplied HTF.

Results
The initial ramp rate is very rapid but as the cooling begins to asymptote at around -25 °C (jacket temperature) the ramp rate begins to slow.
The final temperature is -49 °C in the jacket and approximately -47 °C in the process.



Version: 9/2009

Setup details
Unistat® 510w & Chemglass 50-litre reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250 °C ... 0 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6659)
HTF:	DW-Therm (#6479)
Reactor:	50 litre Chemjacketed glass reactor (un-insulated)
Reactor content:	37 litre M90.055.02 (#6259)
Stirrer speed:	80 rpm
Control:	process

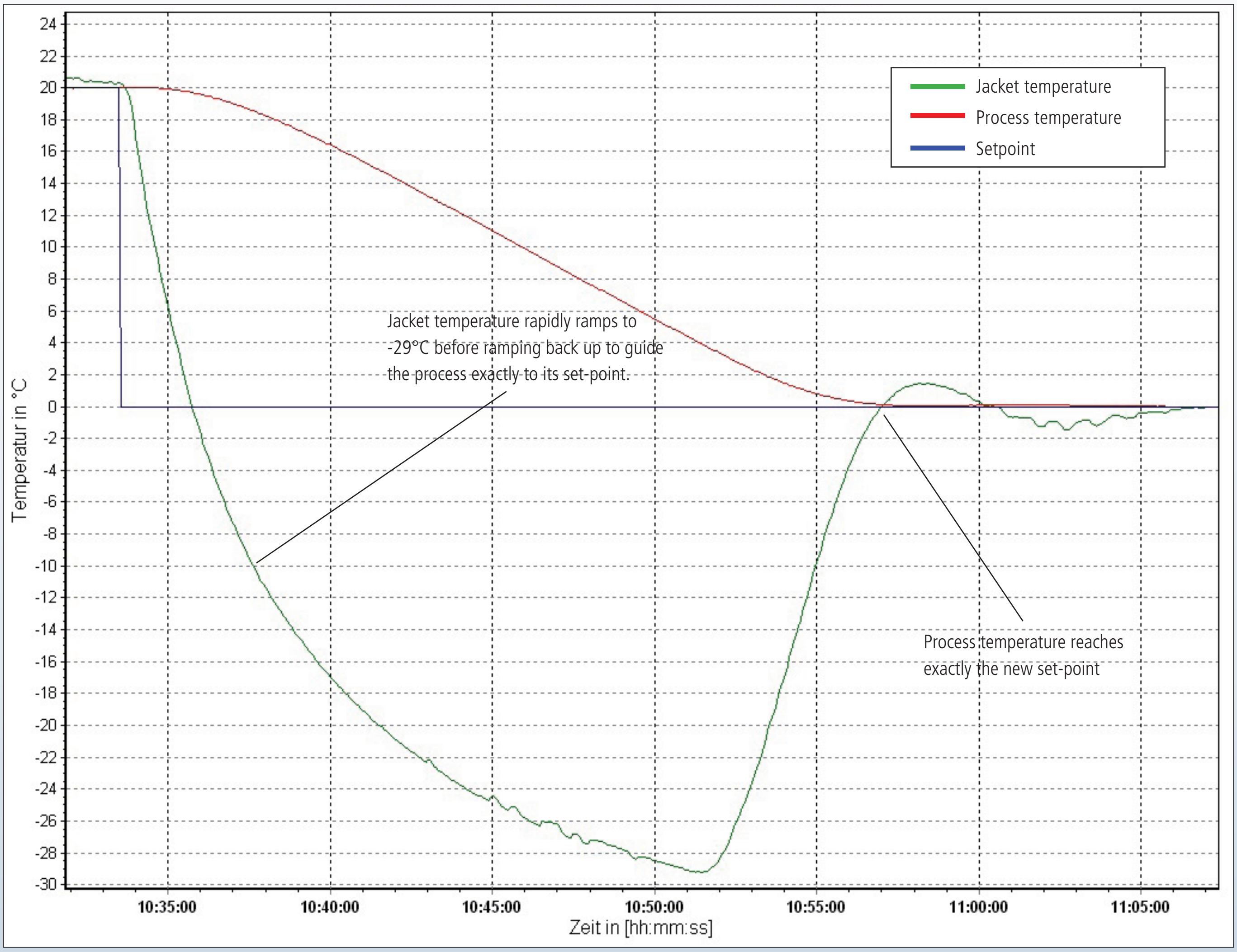
Unistat® 510w

Cooling a Chemglass 50 litre jacketed glass reactor from 20 °C to 0 °C

Requirement
This case study examines the response time when the process set-point is changed from 20 °C to 0 °C in a Chemglass 50-litre jacketed glass reactor.

Method
The Unistat® and reactor were connected using two 1.5 m insulated metal hoses. The reactor was filled with 37 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
It can be seen that the jacket temperature ramps at an average rate of 2.4 K / min to reach -29 °C within 20 minutes before ramping back up to guide the process temperature exactly to its new set-point with negligible under-shoot within 25 minutes.



Version: 9/2009

Unistat® 510w

Cooling a Chemglass 50 litre jacketed glass reactor from 20 °C to "T_{min}"

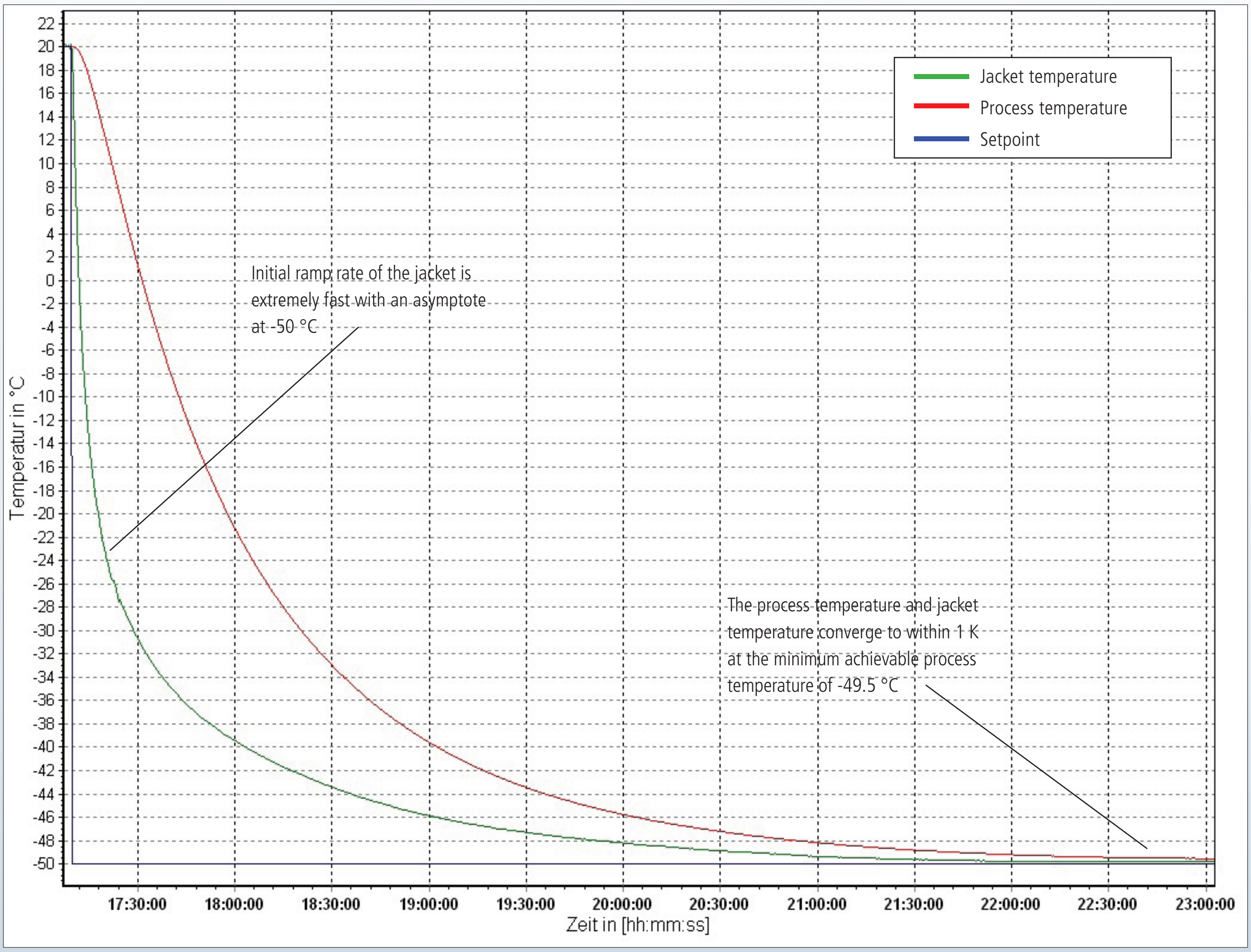
Requirement
This case study examines the minimum achievable process temperature within a Chemglass 50-litre jacketed glass reactor when connected to a Huber Unistat® 510w.

Method
The Unistat® and reactor were connected using two 1.5 m insulated metal hoses. The reactor was filled with 37 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
As can be seen in the graphic, the jacket achieves a temperature of approximately -50 °C and the process temperature asymptotes just above this at approximately -49 °C.

Setup details
Unistat® 510w & Chemglass 50-litre reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250…0 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6659)
HTF:	DW-Therm (#6479)
Reactor:	50 litre Chemglass jacketed reactor (un-insulated)
Reactor content:	37 litre M90.055.02
Stirrer speed:	80 rpm
Control:	process



Setup details
Unistat® 510w & Chemglass 50-litre reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250...0 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6659)
HTF:	DW-Therm (#6479)
Reactor:	50-litre Chemjacketed glass reactor (un-insulated)
Reactor content:	37 litre M90.055.02 (#6259)
Stirrer speed:	80 rpm
Control:	process

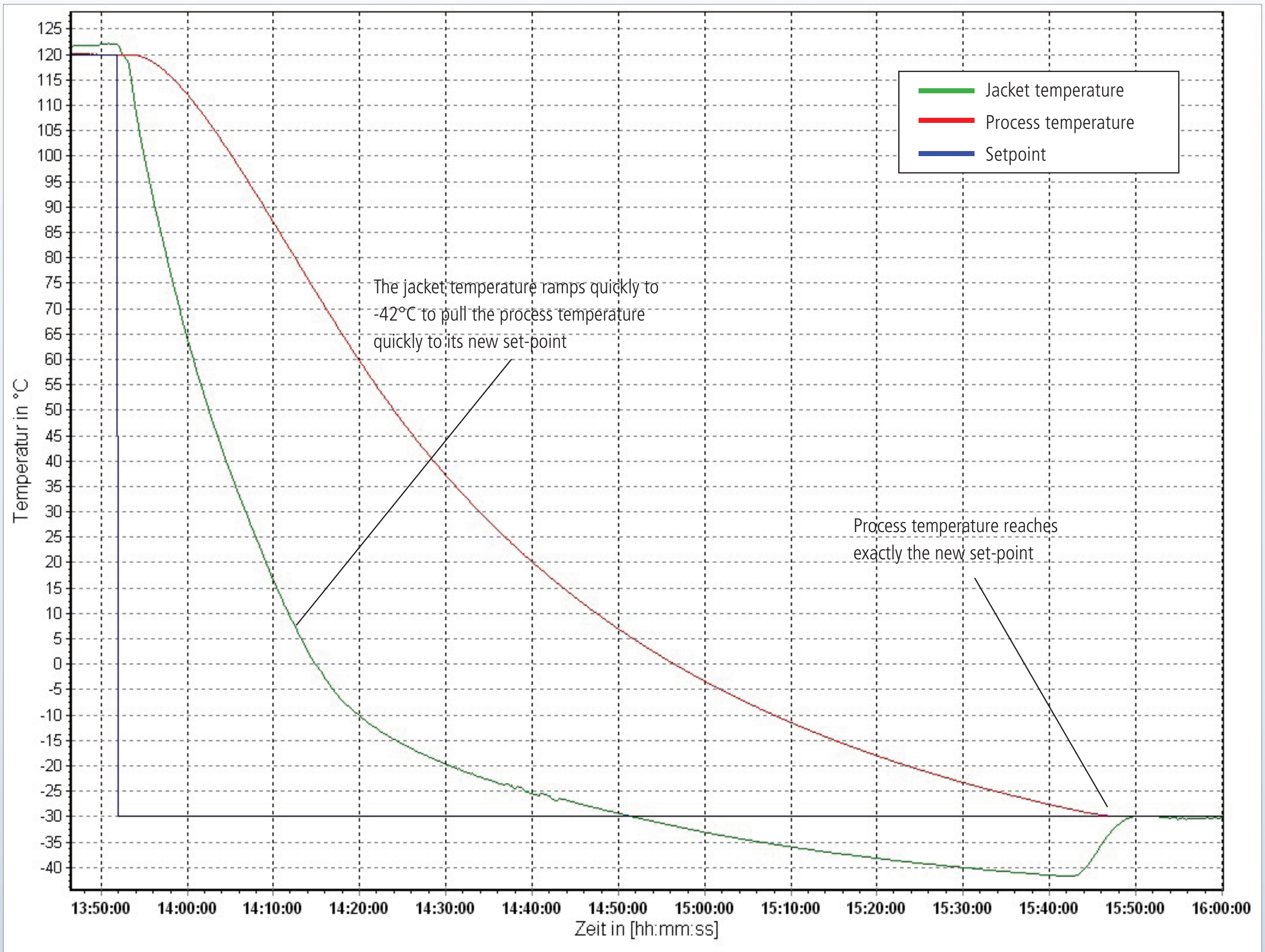
Unistat® 510w

Cooling a Chemglass 50-litre jacketed glass reactor from 120 °C to -30 °C

Requirement
This case study looks at the speed of response to cool a Chemglass 50-litre jacketed glass reactor to -30 °C from 120 °C (150 K).

Method
The Unistat® and reactor were connected using two 1.5 m insulated metal hoses. The reactor was filled with 37 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
It can be seen that the jacket rapidly cools to -42 °C pulling the process temperature towards its new set-point before heating slightly to guide the process to -30 °C with negligible under-shoot.



Version: 9/2009

Unistat® 510w

Heating a Chemglass 50-litre jacketed glass reactor from -50 to 20 °C

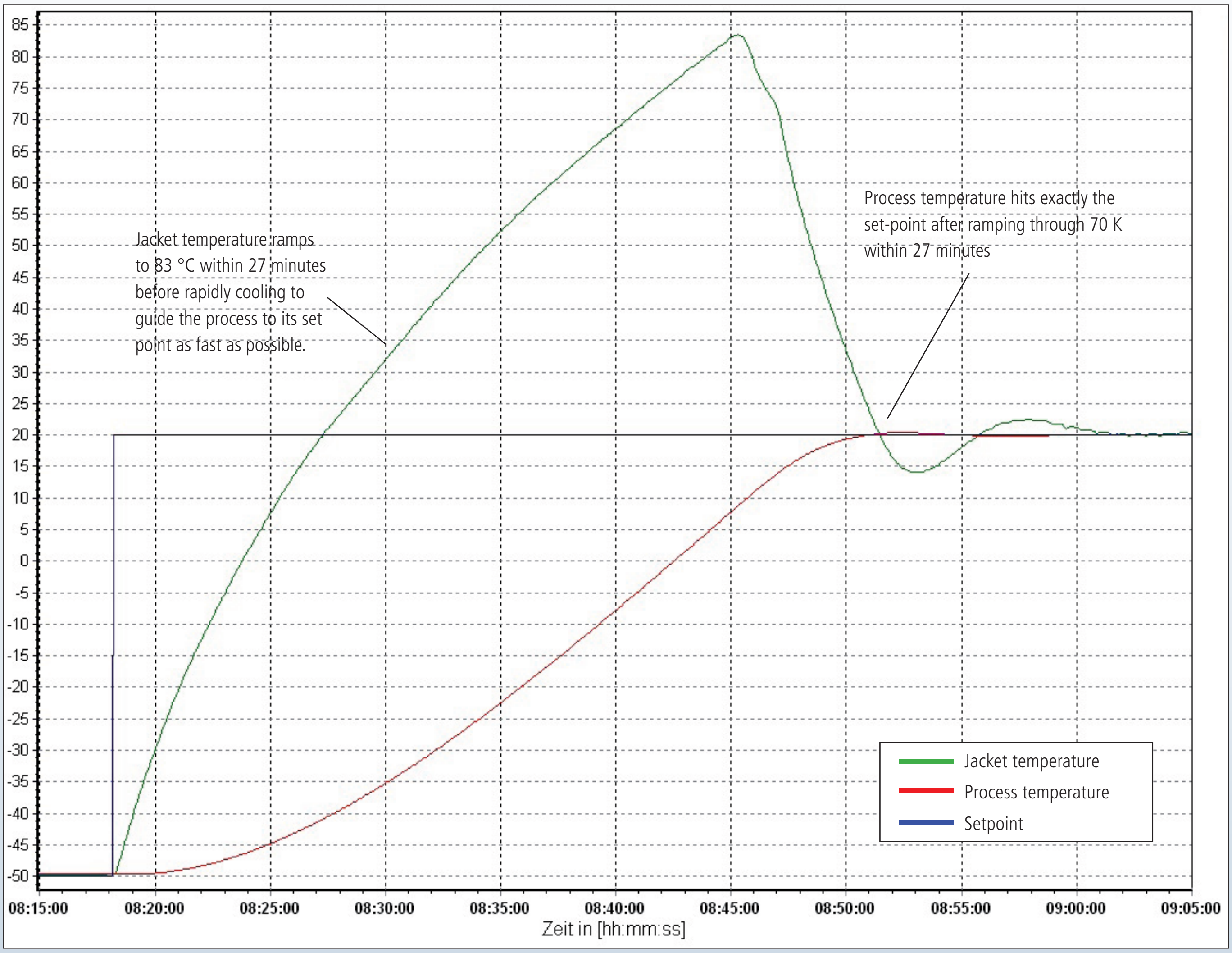
Requirement
This case study looks at the speed of response when the process temperature set-point is changed from -50 °C to 20 °C in a Chemglass 50-litre jacketed glass reactor.

Method
The Unistat® and reactor were connected using two 1.5 m insulated metal hoses. The reactor was filled with 37 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
It can be seen that the jacket temperature ramps rapidly from -50 °C to 20 °C in around 27 minutes (average ramp rate of 4.8 K / min) and as the process approaches its set-point ramping back to guide the process exactly to its new set-point within 32 minutes (average ramp rate of 2 K / min) with a negligible overshoot.

Setup details
Unistat® 510w & Chemglass 50-litre reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250…0 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6659)
HTF:	DW-Therm (#6479)
Reactor:	50-litre Chemjacketed glass reactor (un-insulated)
Reactor content:	37 litre M90.055.02
Stirrer speed:	80 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 510w & Chemglass 50-litre reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250...0 °C 2.8 kW @ -20 °C 0.9 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6659)
HTF:	DW-Therm (#6479)
Reactor:	50-litre Chemjacketed glass reactor (un-insulated)
Reactor content:	37 litre M90.055.02 (#6259)
Stirrer speed:	80 rpm
Control:	process

Unistat® 510w

Controlling simulated exothermic reactions within a Chemglass 50-litre glass-reactor

Requirement

This case study shows the effectiveness of a Unistat® 510w connected to a 50-litre reactor in the control of a three simulated exothermic reactions of differing strengths at 0 °C and 20 °C generated by an electric immersion heater.

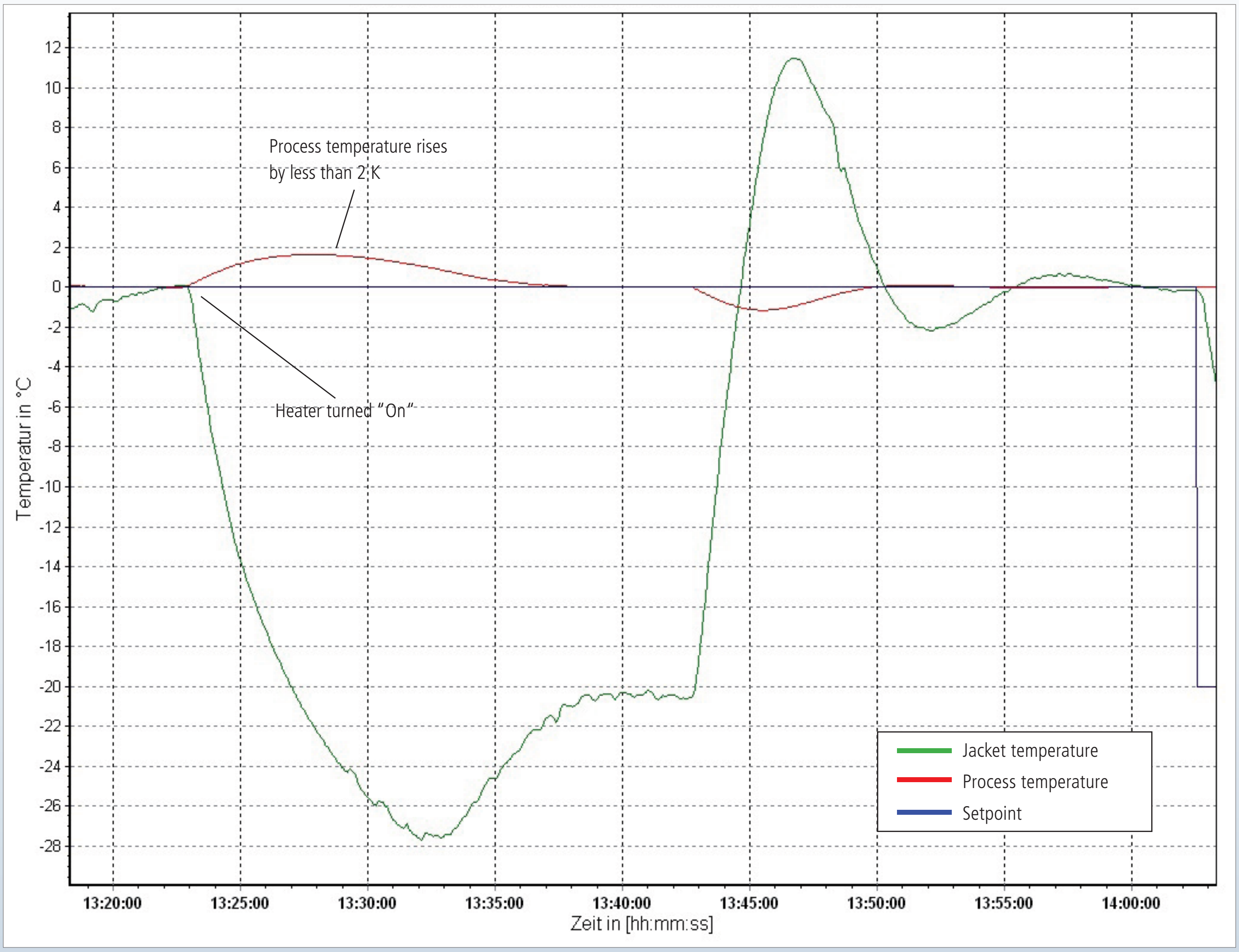
Method

The Unistat® and reactor were connected using two 1.5 m insulated metal hoses. The reactor was filled with 37 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results

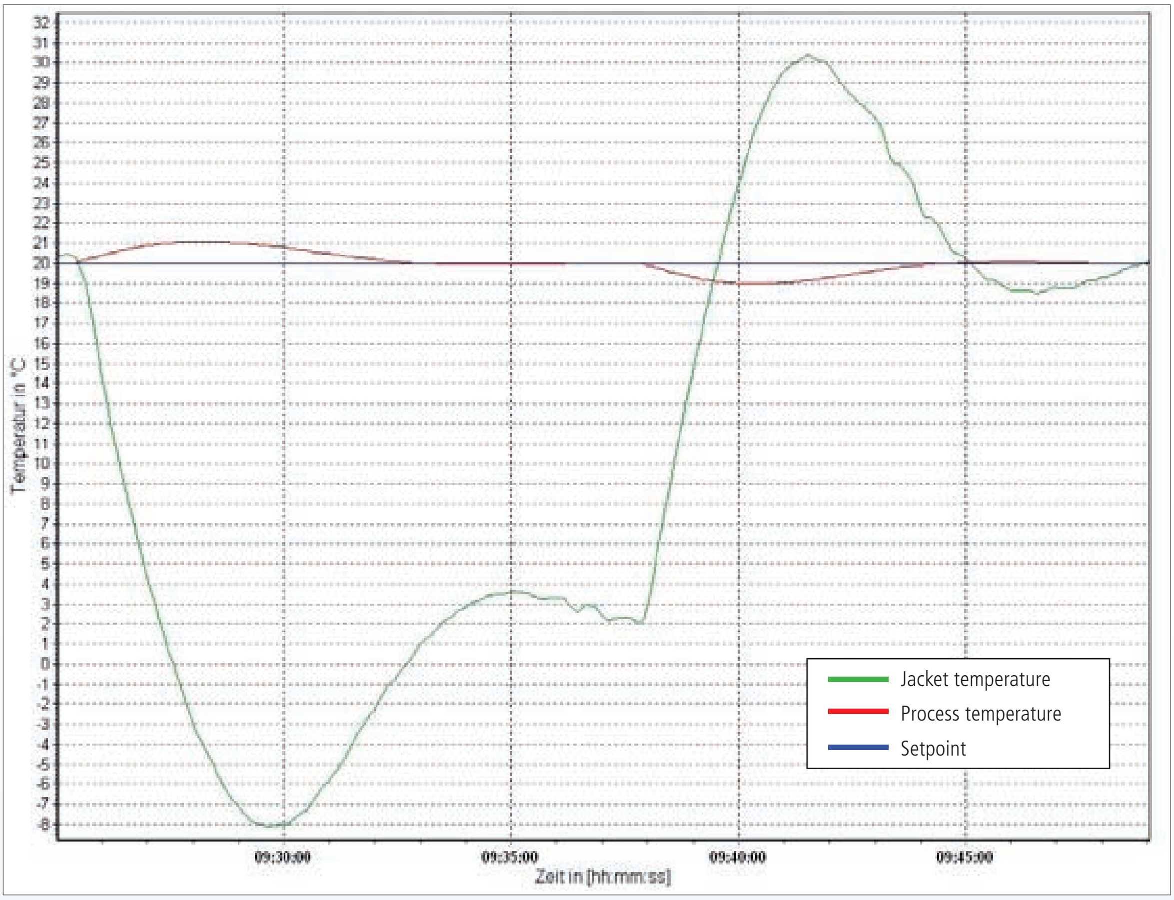
Once the "reaction" was under steady control the heater was turned "Off".
It can be seen how rapidly the ΔT between the process and jacket is increased to "suck" the thermal energy from the process to restore and maintain the process temperature set-point. The results can be viewed in the following graphics.

1. Simulated exothermic of 600 W @ 0 °C

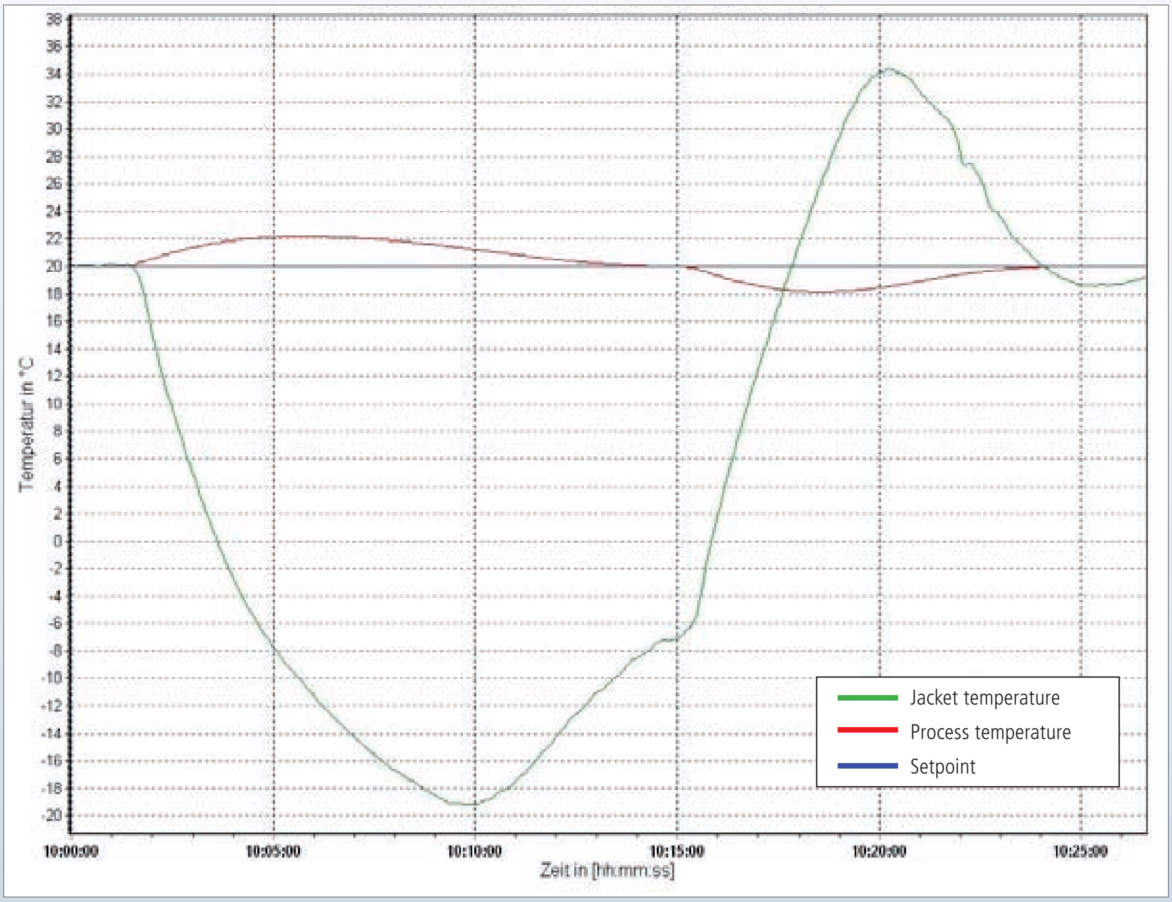


Version: 9/2009

2. Simulated exothermic of 600 W @ 20 °C



3. Simulated exothermic of 900 W @20 °C



Setup details
Unistat® 610w & Radleys reactor

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C
	6.4 kW @ -20 °C
	3.3 kW @ -40 °C
	0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

Unistat® 610w

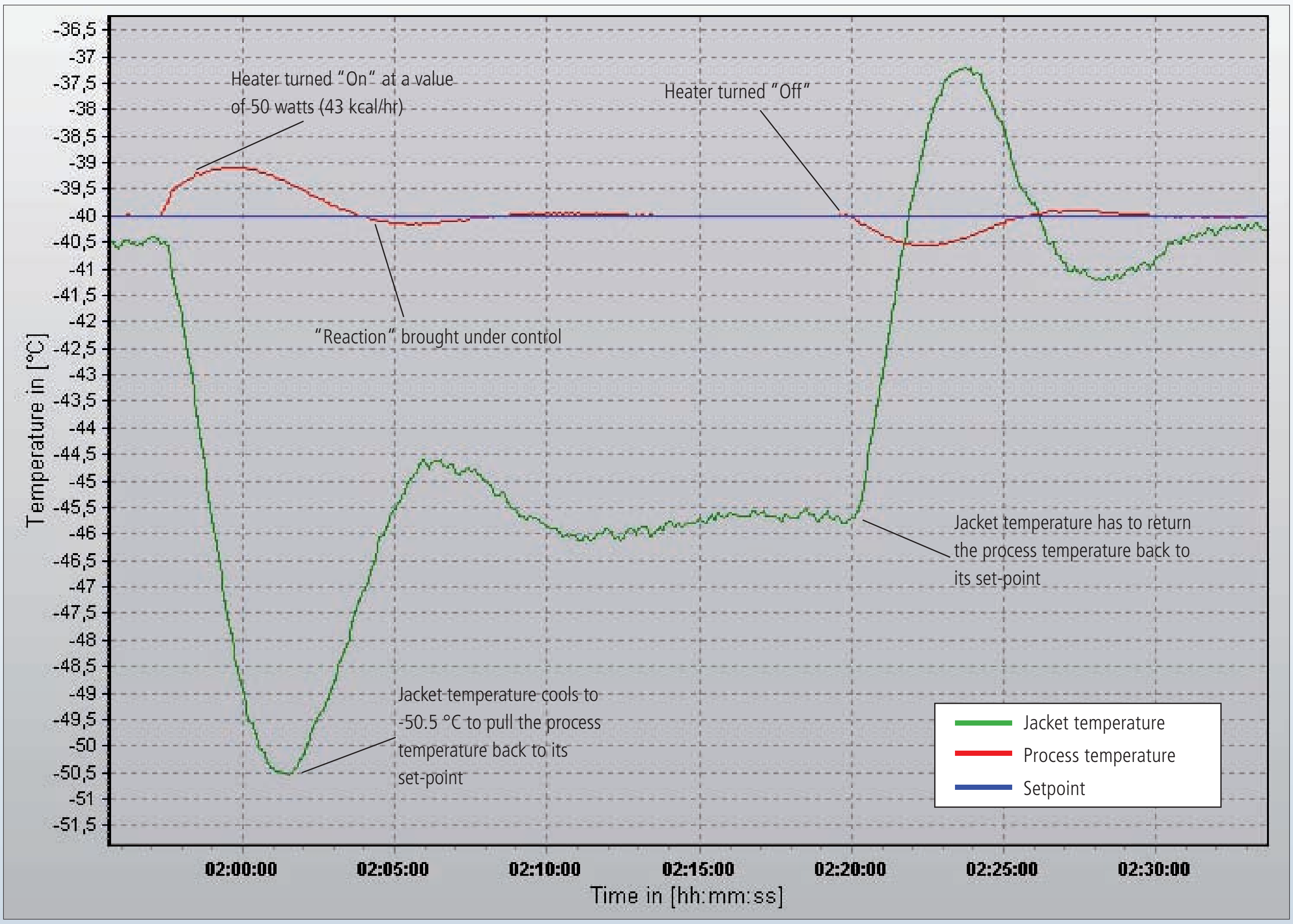
Controlling simulated exothermic reactions at -40 °C in a Radleys 10-litre reactor

Requirement
This case study looks at the response of a Unistat® 610w working to control exothermic reactions in a 10-litre glass reactor at -40 °C.

Method
M30x1.5 hoses are used to connect the setup and the working fluid is DW Therm. The exothermic reactions are conducted with a heating power of 50 W and 100 W.

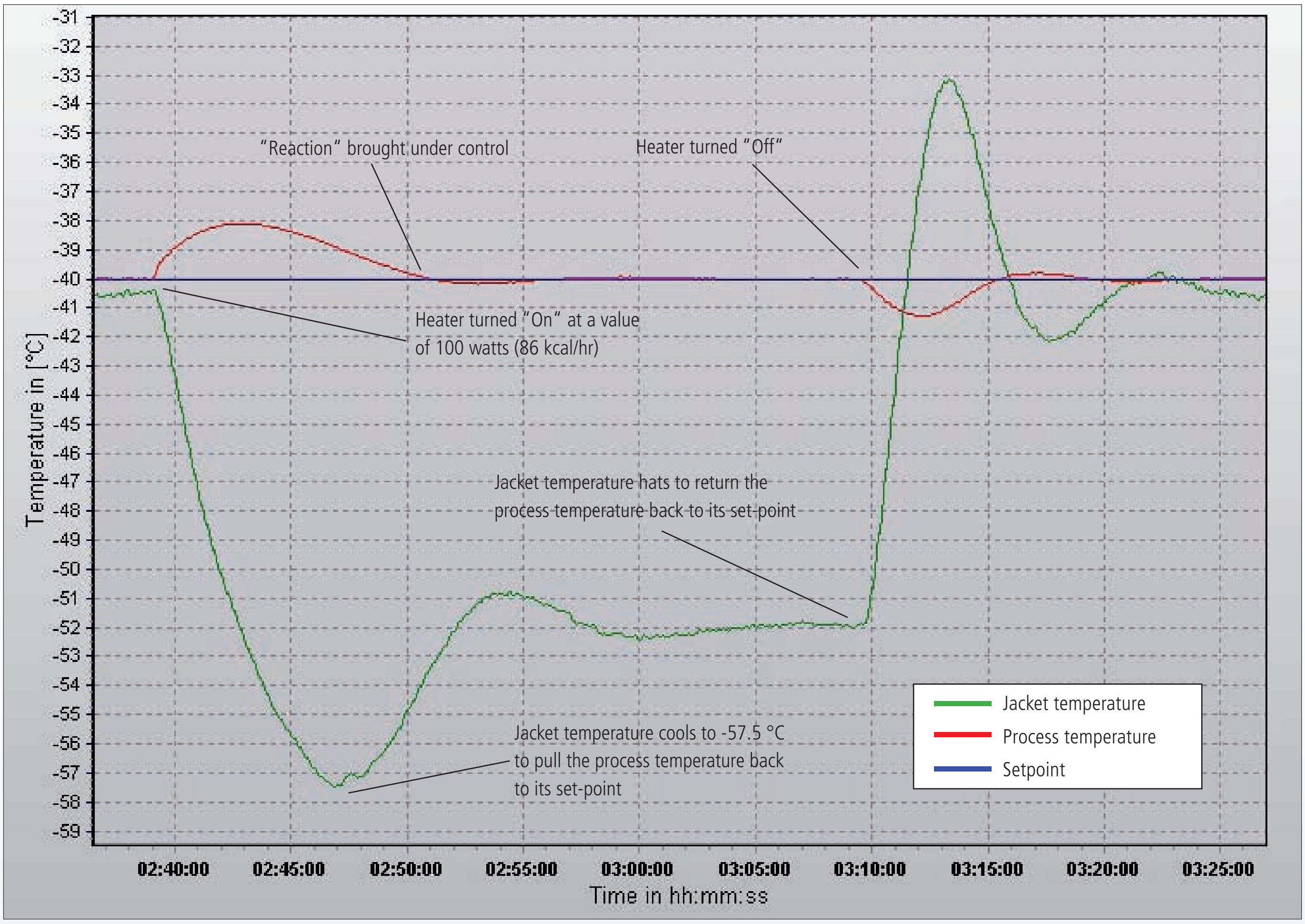
Results
The 50 W heat results in approximately 1 K of temperature rise. With a cooling power of 3.3 kW the unit takes 9 minutes to bring the process temperature back to its set-point. Meanwhile the process temperature rises up to approximately 2 K with the 100 W of heat addition. The internal temperature cools to approximately -57.5 °C in order to pull the process temperature back to -40 °C.
When the heater is switched off, the temperature of the process falls and the thermostat starts heating the jacket in order to return the process temperature to the set point.

Figure 1: Exothermic reaction of 50 W



Version: 9/2009

Figure 2: Exothermic reaction of 100 W



Setup details
Unistat® 610w & Büchi reactor (büchiglasuster)

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content:	15 litre DW-Therm (#6479)
Stirrer speed:	70 rpm
Control:	process

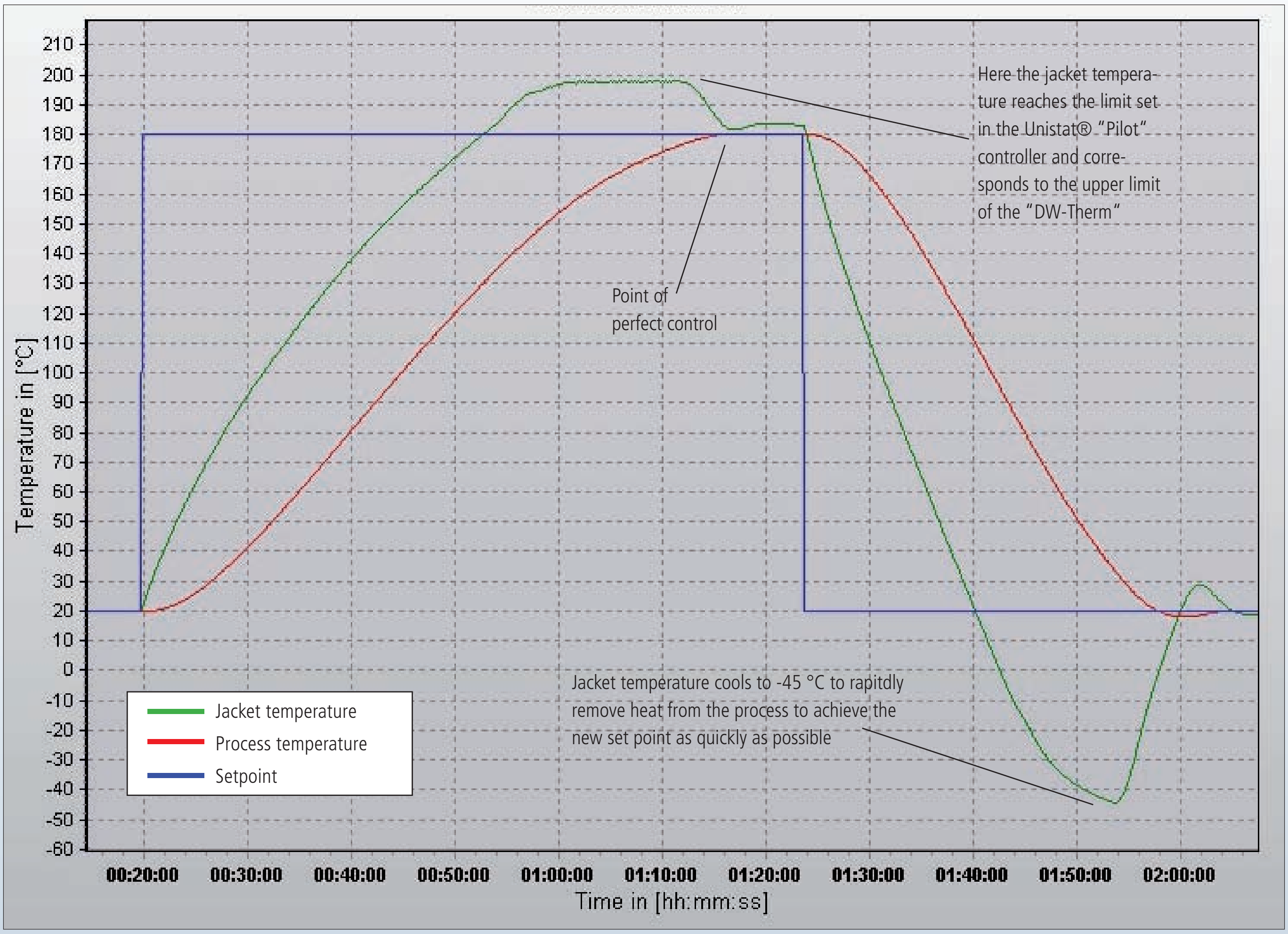
Unistat® 610w

Heating and cooling a Büchi 20-litre glass reactor

Requirement
The graphic shows the performance of Unistat® 610w responding to set-point changes in process temperature of a 20-litre glass reactor from 20 °C to 180 °C and back to 20 °C.

Method
M30x1.5 hoses are used to connect the setup and the working fluid is DW Therm. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The machine needs approximately 60 minutes to reach 180 °C from 20 °C and 41 minutes to cool back to 20 °C. The heating and cooling rates for the processes are 2.67 K / min and 3.9 K / min respectively.



Version: 9/2009

Unistat® 610w

Cooling a Büchi 20-litre jacketed glass reactor to T_{min}

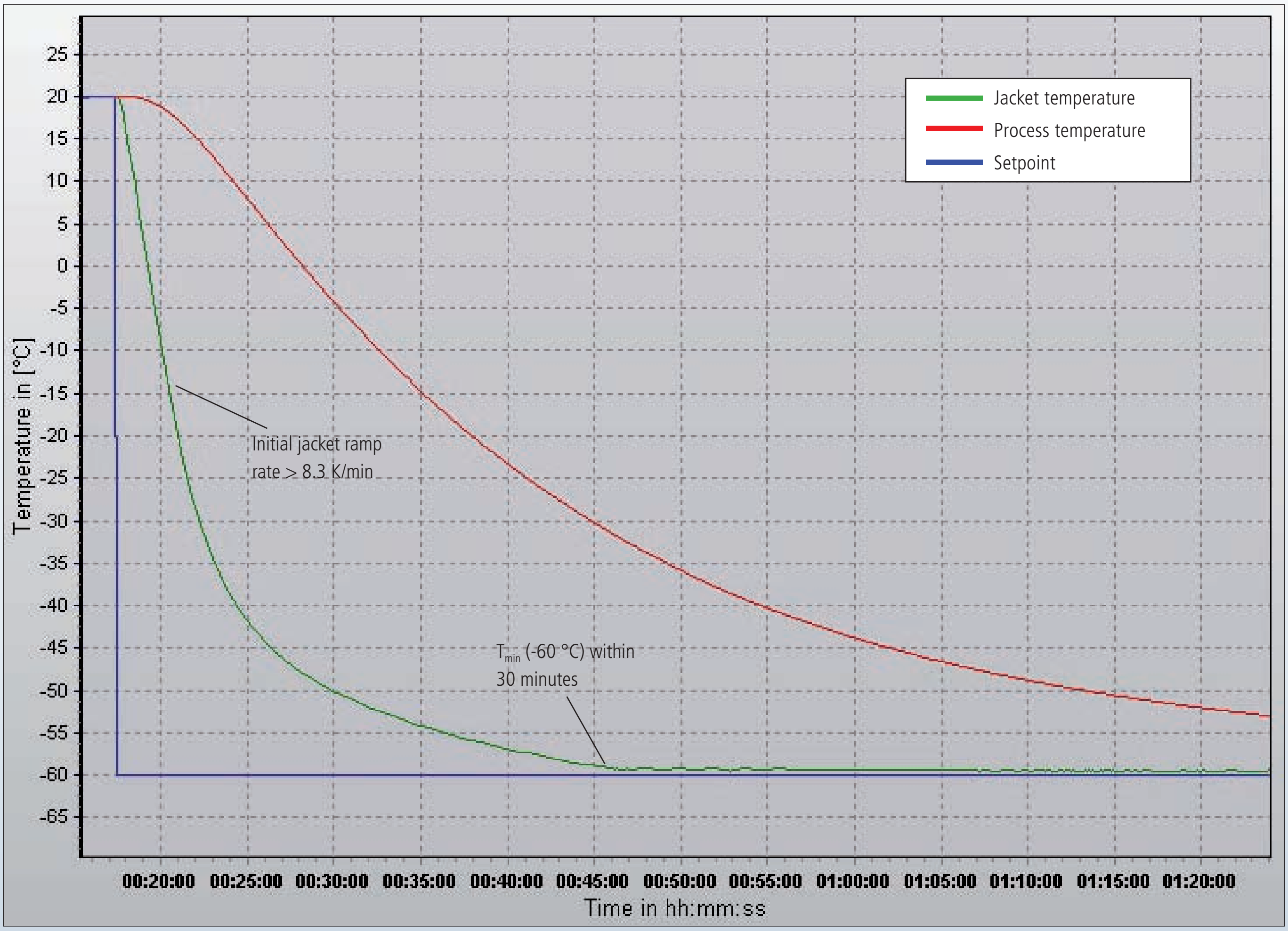
Requirement
This case study shows the performance of a Unistat® 610w with cooling a Büchi 20-litre reactor from 20 °C to -60 °C. M38x1.5 hoses are used in order to get a higher HTF flow rate to the reactor jacket to achieve more efficient heat transfer characteristics.

Method
M30x1.5 hoses are used to connect the set-up and the working fluid is DW Therm.

Results
The "internal" (jacket) temperature takes 29 minutes to reach the minimum possible temperature of -59.5 °C. It pulls down the process temperature at a rate of 1.1 K / min. After 65 minutes there is a temperature difference of 6 K between the jacket and process temperatures.
For a machine of 0.8 kW of cooling power at -60 °C, the ramp rate is very fast considering the size of the reactor.

Setup details
Unistat® 610w & Büchi reactor (büchiglasuster)

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content:	15 litre DW-Therm (#6479)
Stirrer speed:	70 rpm
Control:	internal



Version: 9/2009

Setup details
Unistat® 610w & Büchi «miniPilot» 10 reactor

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass pressure reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	internal

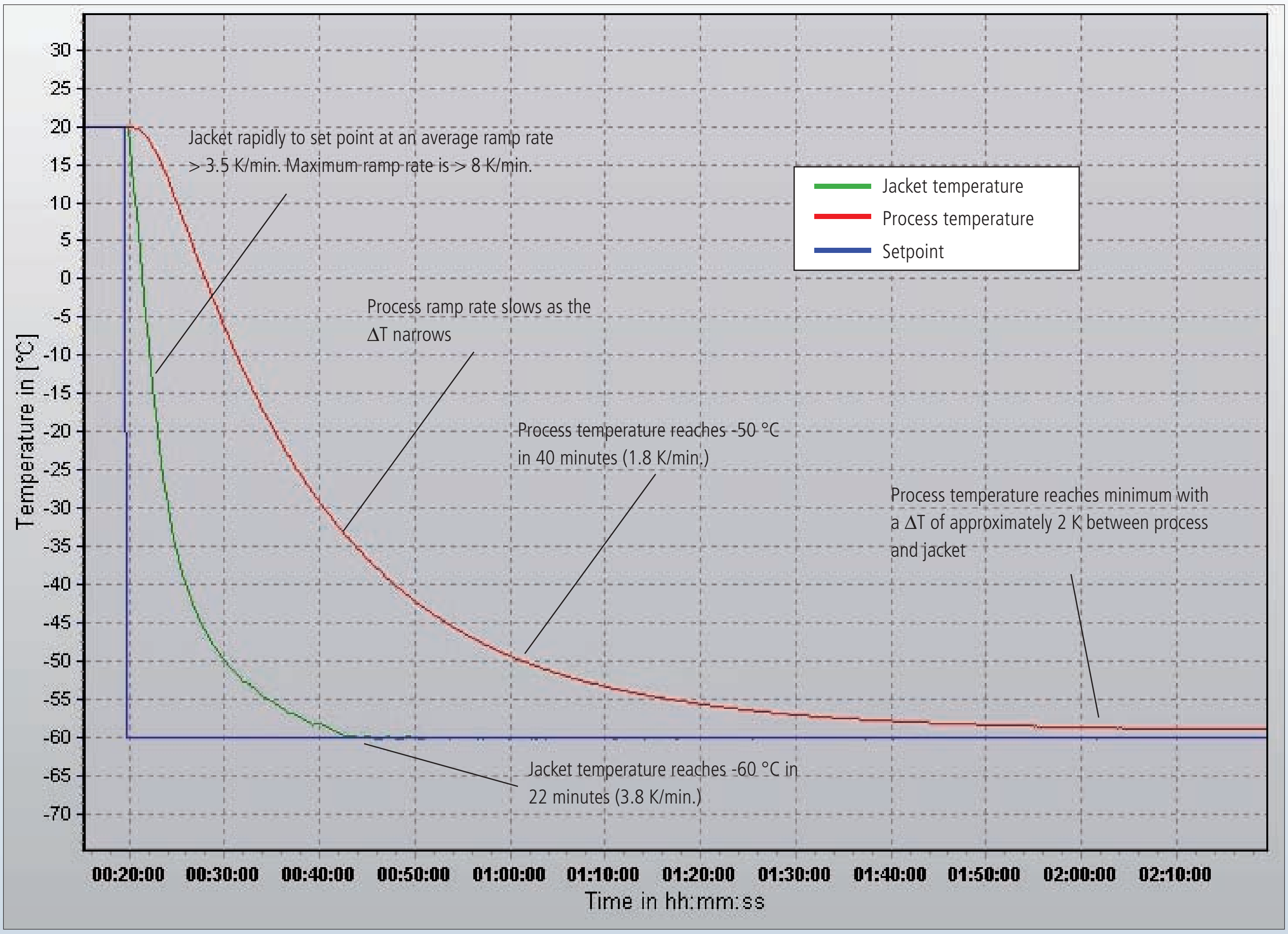
Unistat® 610w

T_{min} with "internal" or "jacket" control on a 10-litre glass reactor

Requirement
The test is conducted to investigate the performance of a Unistat® 610w working under „internal" (jacket) temperature control. M30x1.5 hoses are used to connect the machine with a 10-litre glass reactor. DW-Therm is used as the HTF.

Method
The reactor and Unistat® are connected using two 1.5 metre insulated hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The graphic illustrates that the Unistat® needs only 21 minutes to reach the minimum jacket set-point temperature of -60 °C. With only 0.8 kW of cooling power at -60 °C the process temperature is pulled down to -56 °C in 60 minutes. Then, at the end of the 105-minute-segment a ΔT of 2 K exists between the process and jacket.



Unistat® 610w

200 W (172 kcal / min) & 300 W (258 kcal / hr) exothermic reactions @ 0 °C in a Radleys 10-litre jacketed glass reactor

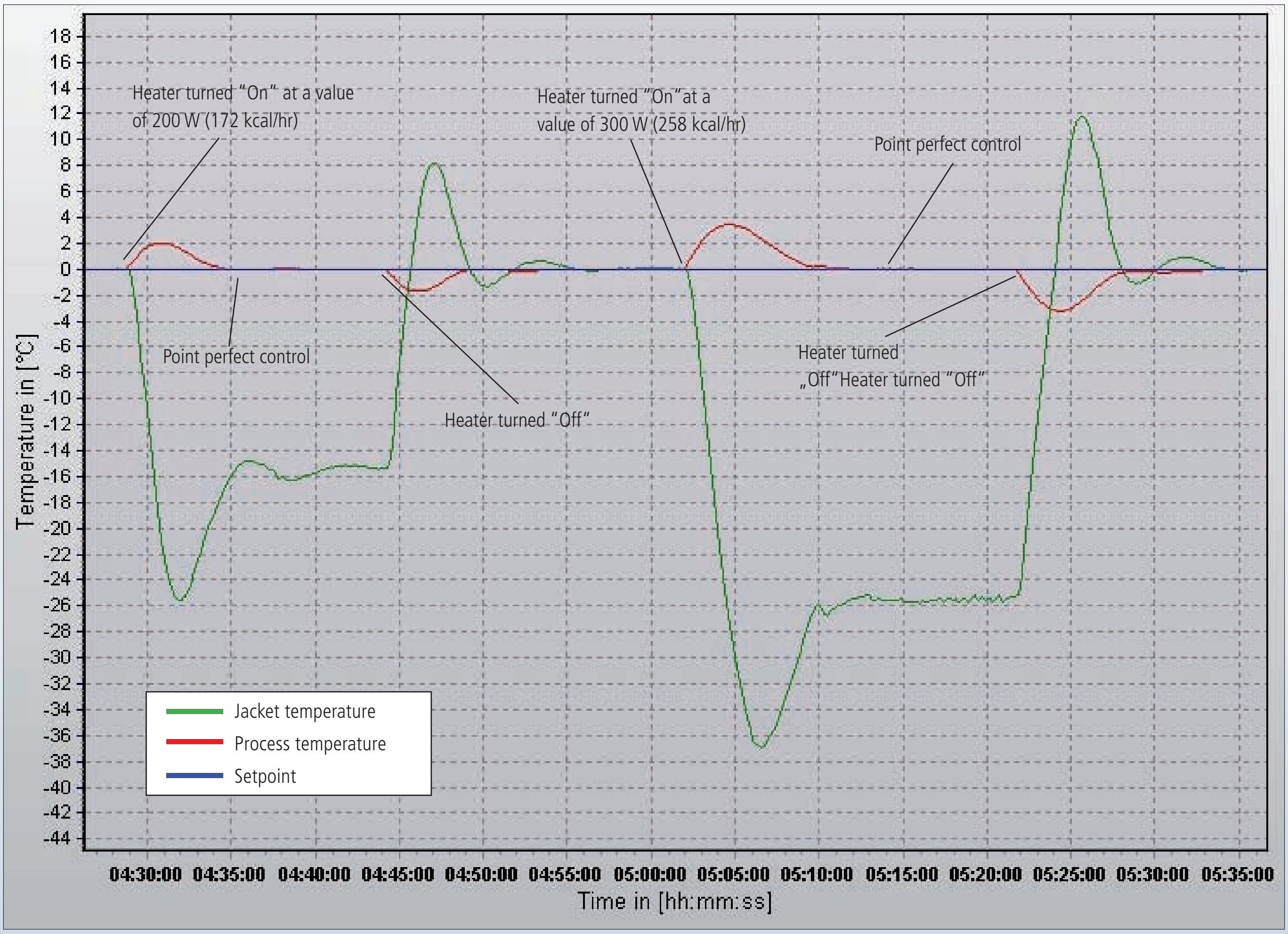
Requirement
A Unistat® 610w is used to control process temperature during simulated exothermic reactions is a Radleys 10-litre glass reactor.

Method
The reactor and Unistat® are connected withtwo M30x1.5 insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The heat generated by the 200 W simulated exothermic reaction results in a temperature rise of 2 °C. The Unistat® 610w cools the jacket at a rate of 8.5 K / min to -25.7 °C in order to bring the process temperature back to the set-point of 0 °C within 6 minutes. The second test with a simulated exothermic reaction of 300 W results in a process temperature rise of 3.5 °C. The jacket temperature rapidly cools to -37 °C in just 4 minutes and pulls the process temperature back to 0 °C in 8 minutes.

Setup details
Unistat® 610w & Radleys reactor

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 610w & Radleys reactor

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C
	6.4 kW @ -20 °C
	3.3 kW @ -40 °C
	0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process

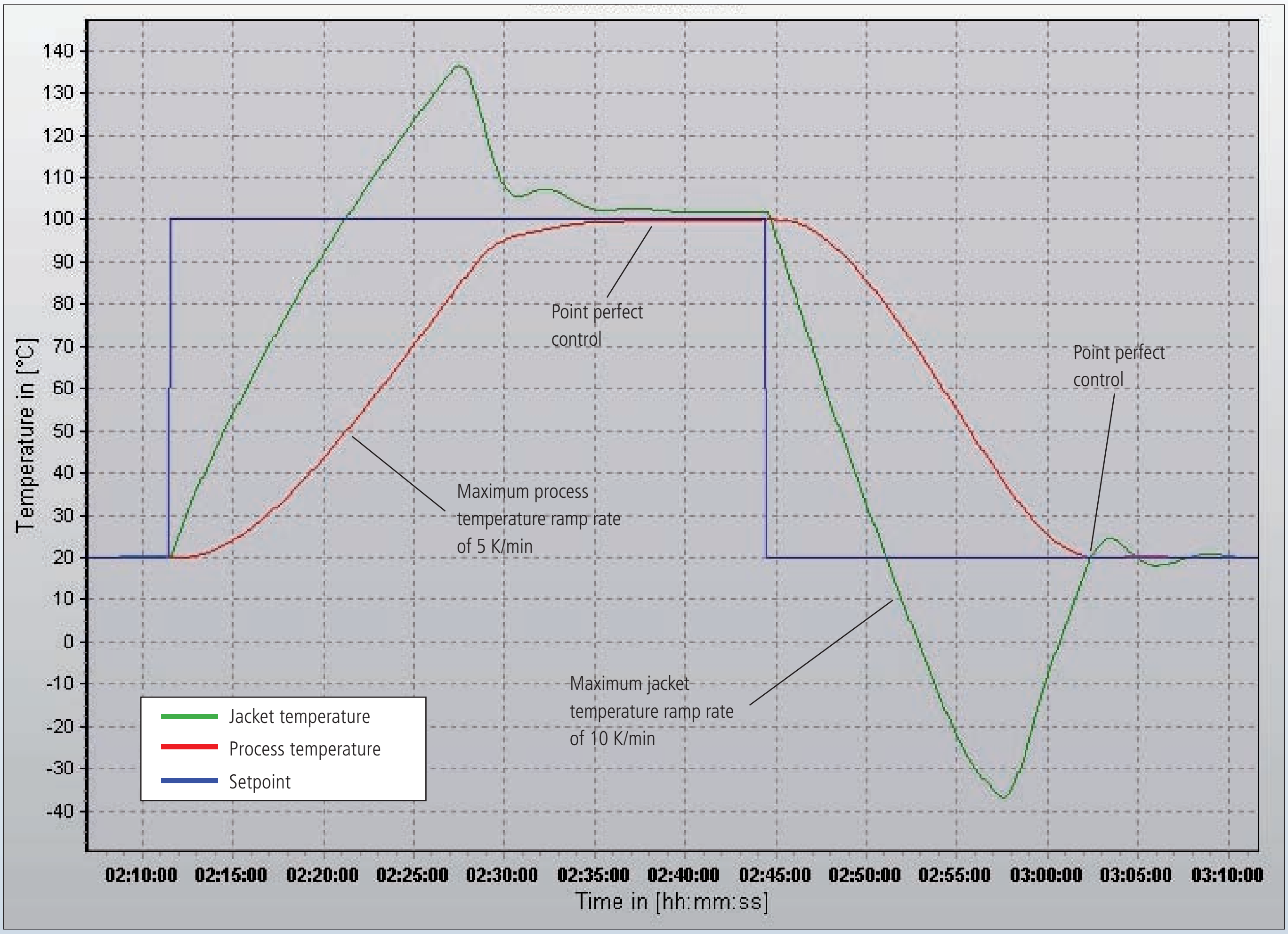
Unistat® 610w

Heating and cooling a Radleys 10-litre jacketed glass reactor

Requirement
This case study shows the temperature profile of a Unistat® 610w heating and cooling a Radleys 10-litre glass reactor between 20 °C and 100 °C.

Method
The reactor and Unistat® are connected withtwo M30x1.5 insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The Unistat® 610w takes 28 minutes to heat the 10-litre glass reactor from 20 °C to 100 °C. This is an average heating rate of 2.9 K / min as can be seen on the process temperature curve. Cooling the process between the same temperature range occurs at a average rate of 3.5 K / min.



Version: 9/2009

Unistat® 610w

Control dynamics on a Büchi 20-litre reactor

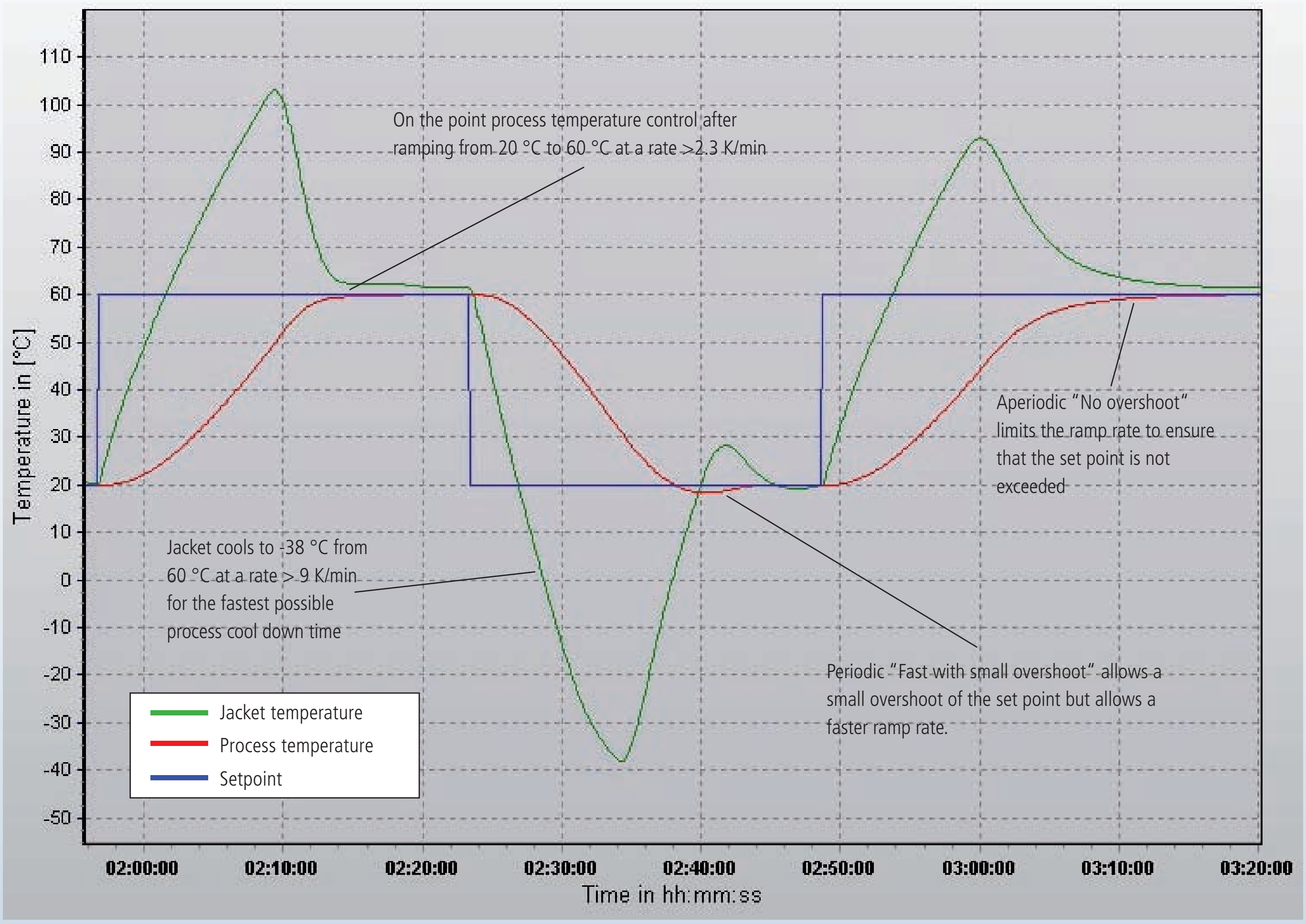
Requirement
Every Unistat® can be set to ramp "Fast with small over shoot" or "No overshoot". This case study looks at the response under different "control dynamics" of a Unistat® 610w when cooling and heating a Büchi 20-litre reactor between 20 °C and -60 °C.

Method
The Unistat® and reactor were connected using two 1.5 m insulated metal hoses. The reactor was filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The first & second curves (20 °C to 60 °C and back to 20 °C) show the function of "Periodic - fast, small overshoot" control dynamic. The first curve illustrates a heating process in a time of 16 minutes. It can be clearly seen that the internal temperature heats to 103 °C, thus the process temperature reaches 60 °C very quickly. The Unistat® 610w cools the 20-litre reactor back to 20 °C in approximately 17 minutes through a ΔT of 40 K.
The third curve (20 °C to 60 °C) shows the same temperature profile but with "Aperiodic - no overshoot" control. The Unistat® takes slightly longer (30 minutes) to heat to avoid any over or undershoot of the set-point.

Setup details
Unistat® 610w & Büchi reactor (büchiglasuster)

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content:	15 litre DW-Therm (#6479)
Stirrer speed:	70 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 610w & Büchi reactor (büchiglasuster)

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass pressure reactor
Reactor content:	15 litre DW-Therm (#6479)
Stirrer speed:	70 rpm
Control:	process

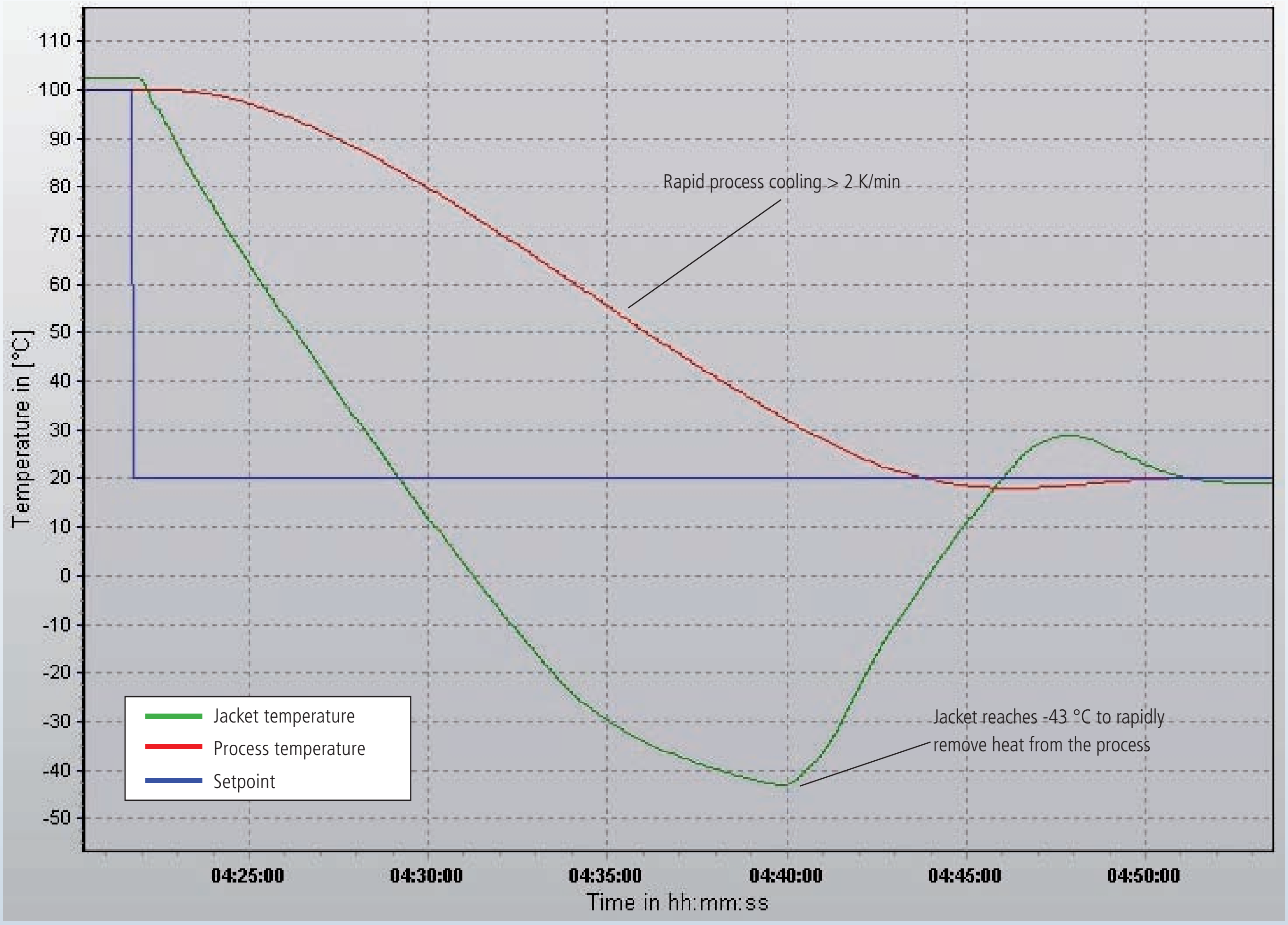
Unistat® 610w

Cooling a Büchi 20-litre reactor from 100 °C to 20 °C

Requirement
This case study shows the temperature profile of a Unistat® 610w working to cool a 20-litre reactor from 100 °C to 20 °C.

Method
The Unistat® and reactor were connected using two 1.5 m insulated metal hoses. The reactor was filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The jacket temperature cools to approx. -43 °C to bring the process temperature rapidly to its set point in 40 minutes.



Version: 9/2009

Technical details and dimensions are subject to change. No liability is accepted for errors or ommisions.

Unistat® 610w

Heating a Radleys 10-litre glass reactor from 20 °C to 180 °C.

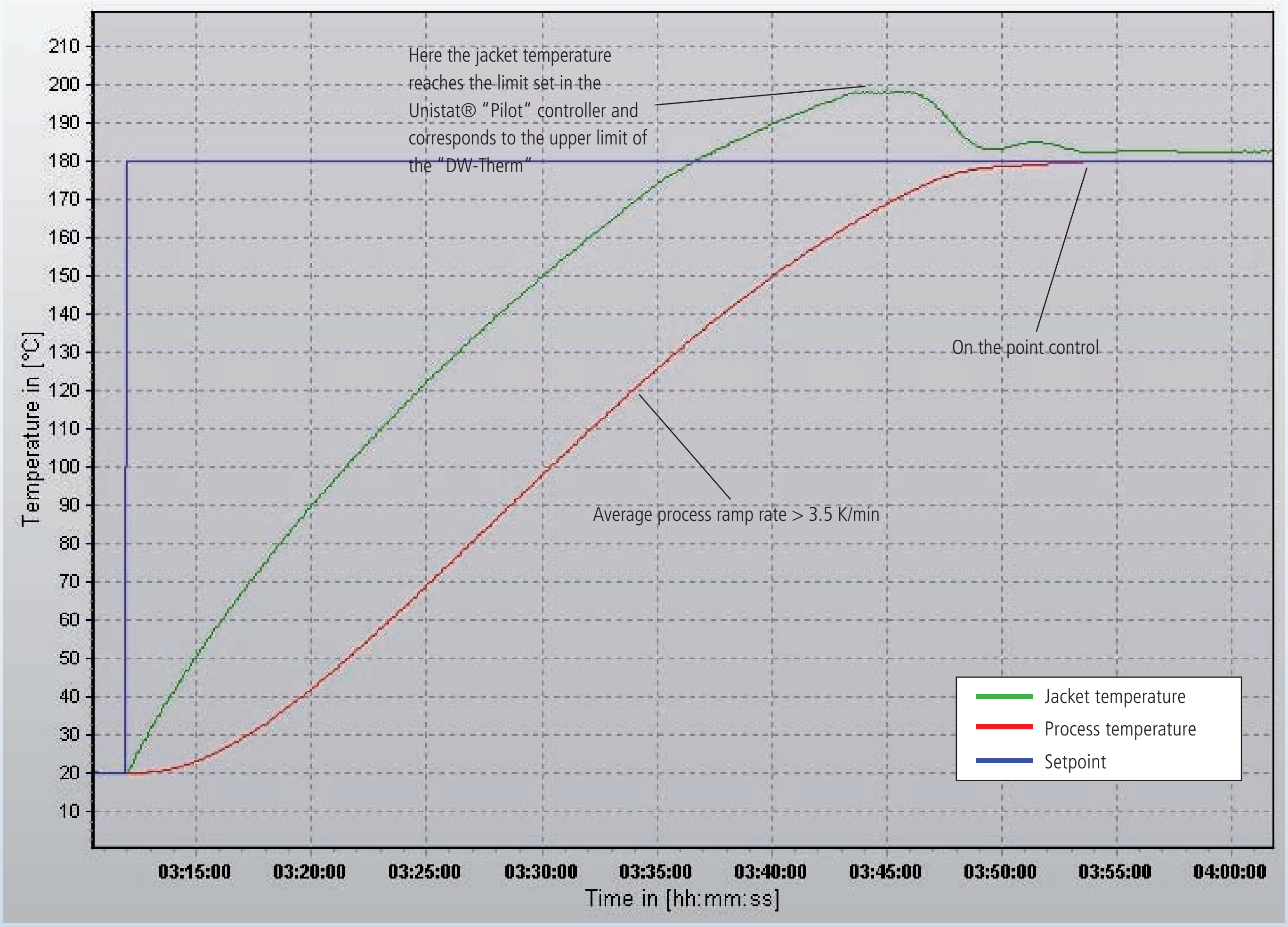
Requirement
This case study illustrates the performance of a Unistat® 610w heating a Radleys 10-litre glass reactor from 20 °C to 180 °C.

Method
The reactor and Unistat® are connected using two 1.5 metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The heating curve shows that the Unistat® 610w takes 45 minutes to reach a set-point of 180 °C. The „internal" (jacket) temperature is limited to 200 °C because of the upper temperature limit of the HTF (DW-Therm).

Setup details
Unistat® 610w & Radleys 10-litre reactor

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 610w & Radleys reactor

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

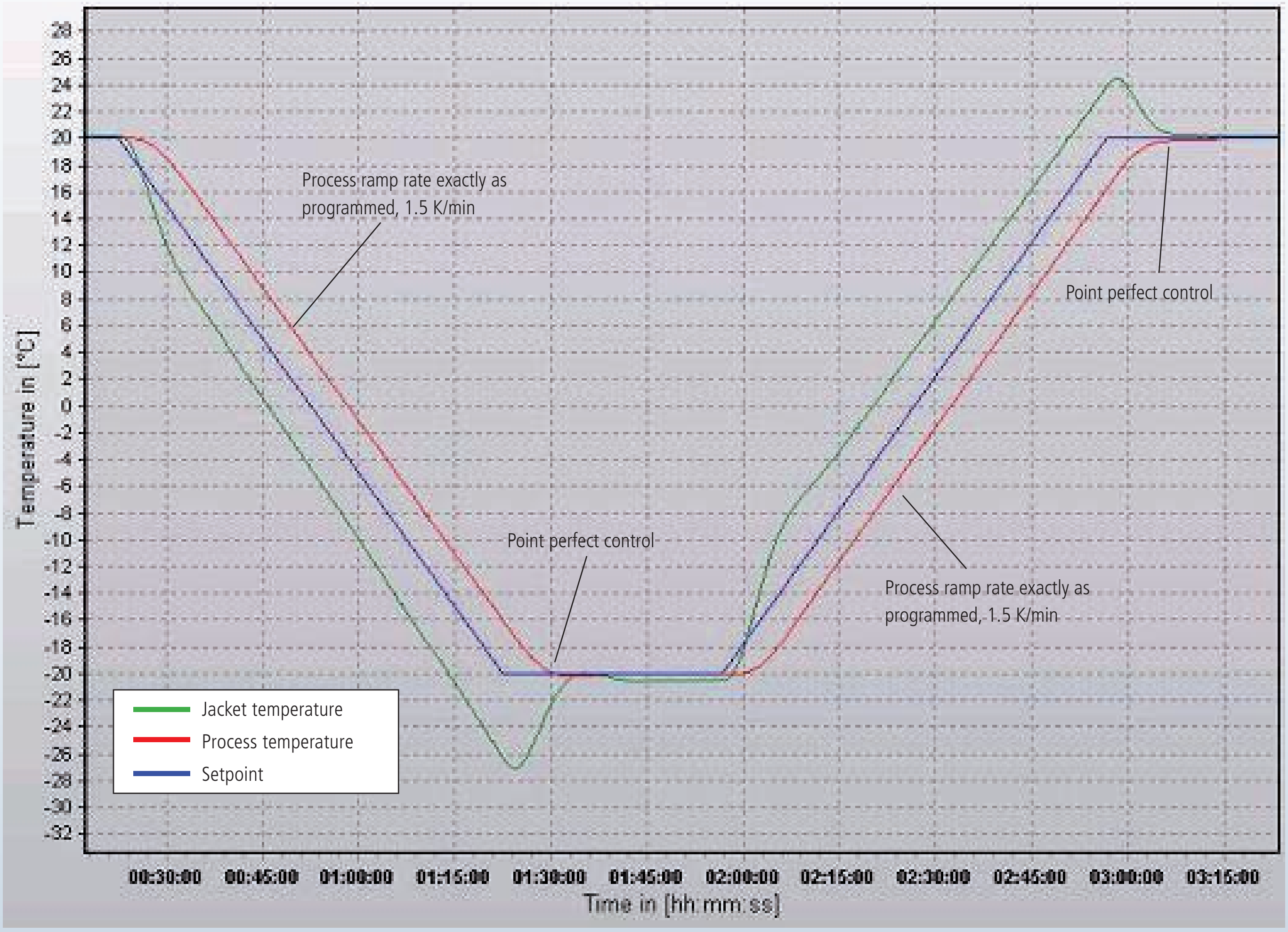
Unistat® 610w

Linear Ramping a Radleys 10-litre jacketed glass reactor

Requirement
This case study demonstrates the ramp rate set to cool then heat the process from 20 °C to -20 °C in 60 minutes (1.5 K / min) then back to 20 °C over the same time period.

Method
The reactor and Unistat® are connected using two 1.5 metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process ramp is uniform. The control is point-perfect to the setpoints with no overshoot.



Version: 9/2009

Unistat® 610w

Simple setpoint change

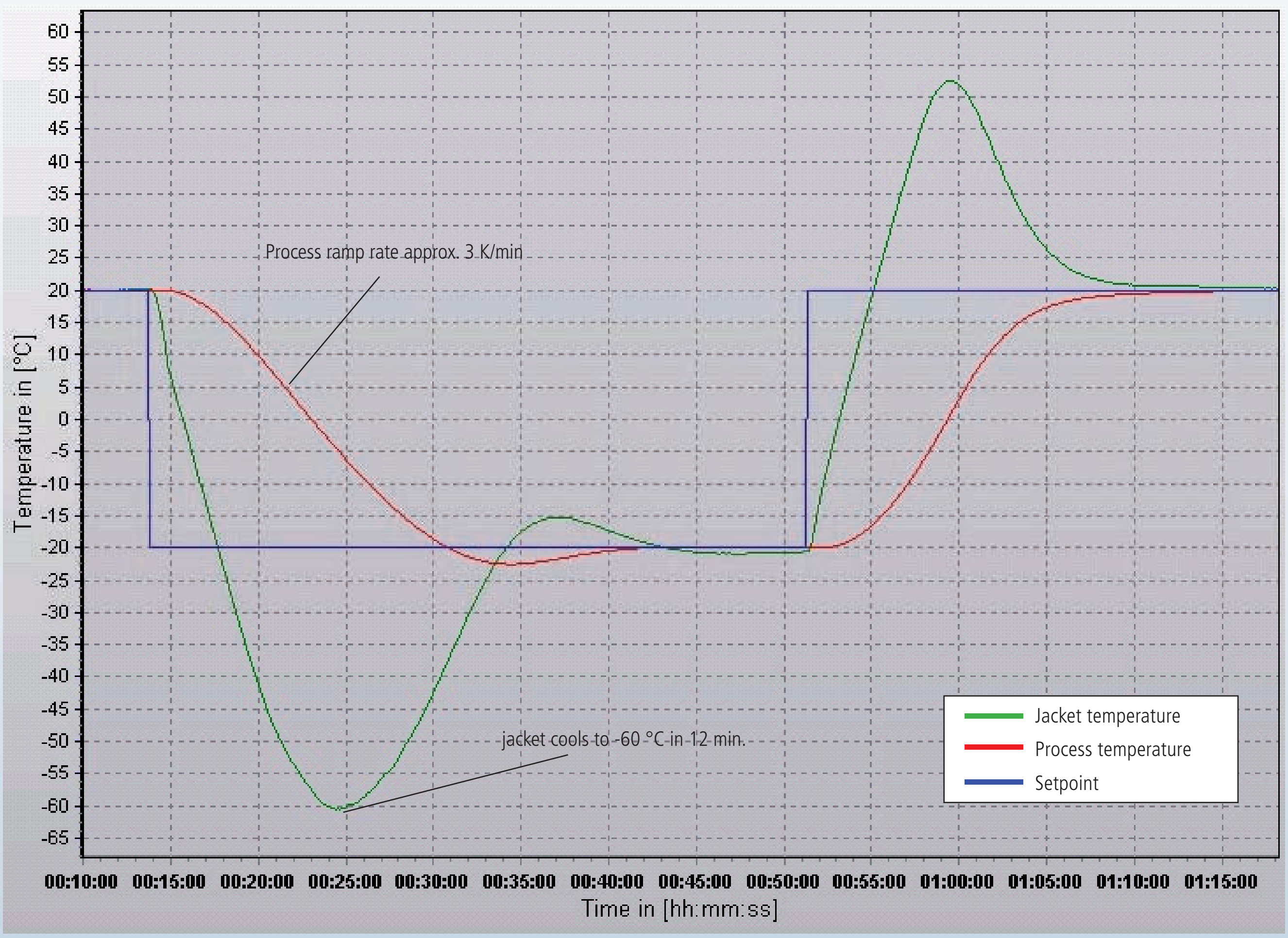
In this case study, the Unistat® 610w responds to a change in set point and cools and heats the process as fast as possible.

Method
The reactor and Unistat® are connected using two 1.5 metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
This graphic demonstrates the capability of a Unistat® 610w when connected to a 10-litre jacketed glass reactor. The speed of response of the jacket temperature can be seen in the rapid ramping rate from 20 °C to -60 °C within 12 minutes.

Setup details
Unistat® 610w & Radleys reactor

Temperature range:	-60...200 °C
Cooling power:	7.0 kW @ 200…0 °C 6.4 kW @ -20 °C 3.3 kW @ -40 °C 0.8 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259) specific heat capacity of 0.36 kcal / kg K
Stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Unistat® 615w

Heating and cooling a 250-litre GLSS Büchi reactor

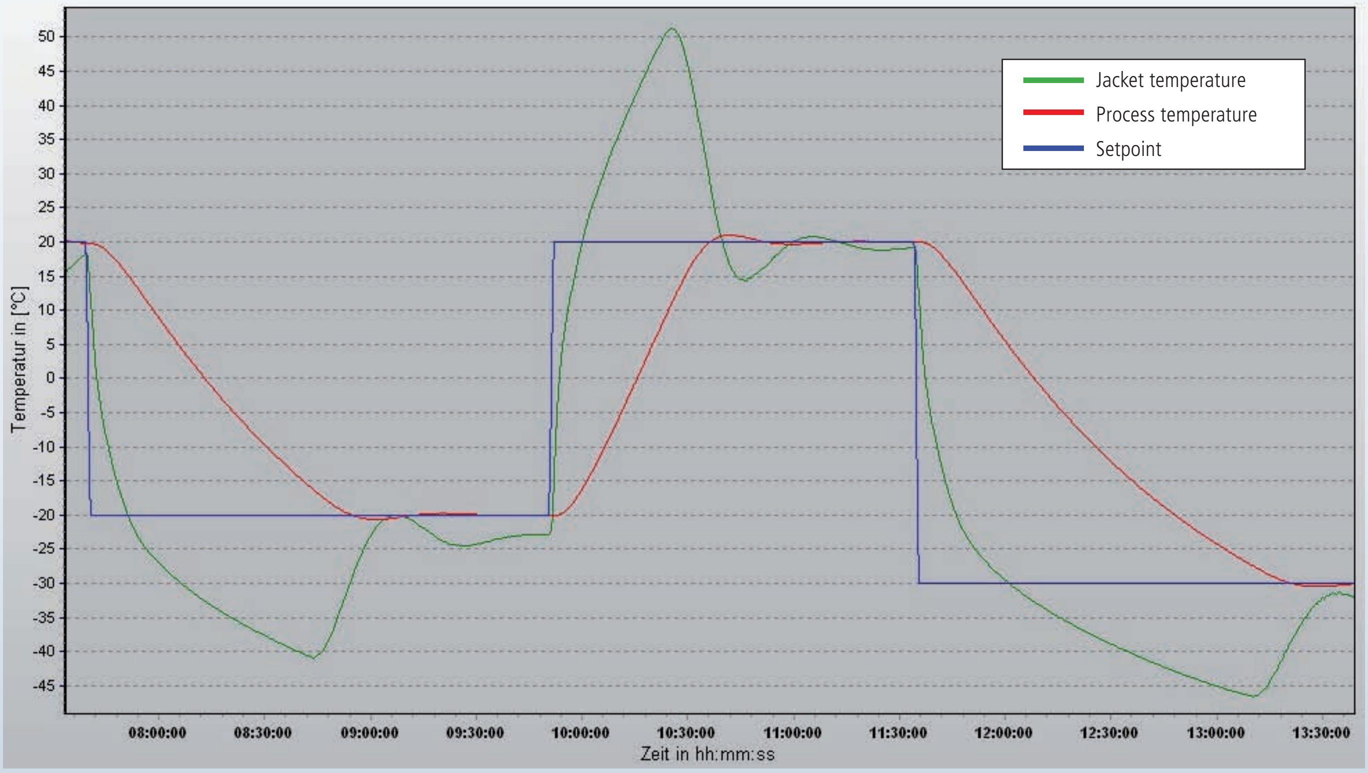
Setup details

Temperature range:	-60...200 °C
Cooling power:	9.5 kW @ 200…0 °C
	8.0 kW @ -20 °C
	4.8 kW @ -40 °C
	1.2 kW @ -60 °C
Heating power:	12 kW
Hoses:	M38x1,5; 2x2 m
HTF:	DW-Therm
Reactor:	Büchi CR252
	250-litre glass-lined (enameled) steel reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process

Requirement
This case study shows the remarkable power transfer capabilities of the Unistat® range in using a Unistat® 615w to heat and cool a 250-litre Büchi GLSS reactor.

Method
The Unistat® was connected to the reactor using two 2-metre insulated metal hoses. The reactor was filled with 200 litre of Ethanol.

Results
Cooling from 20 °C to -20 °C takes approximately 60 minutes and heating back to 20 °C taking approximately 40 minutes. The third curve shows a cool down time from 20 °C to -30 °C (50 K) taking approximately 110 minutes.



Version: 9/2009

Setup details

Temperature range:	–60...200 °C
Cooling power:	9.5 kW @ 200…0 °C
	8.0 kW @ -20 °C
	4.8 kW @ -40 °C
	1.2 kW @ -60 °C
Heating power:	12 kW
Hoses:	M38x1,5; 2x2 m
HTF:	DW-Therm
Reactor:	Büchi CR252
	250-litre glass-lined
	(enameled) steel reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process

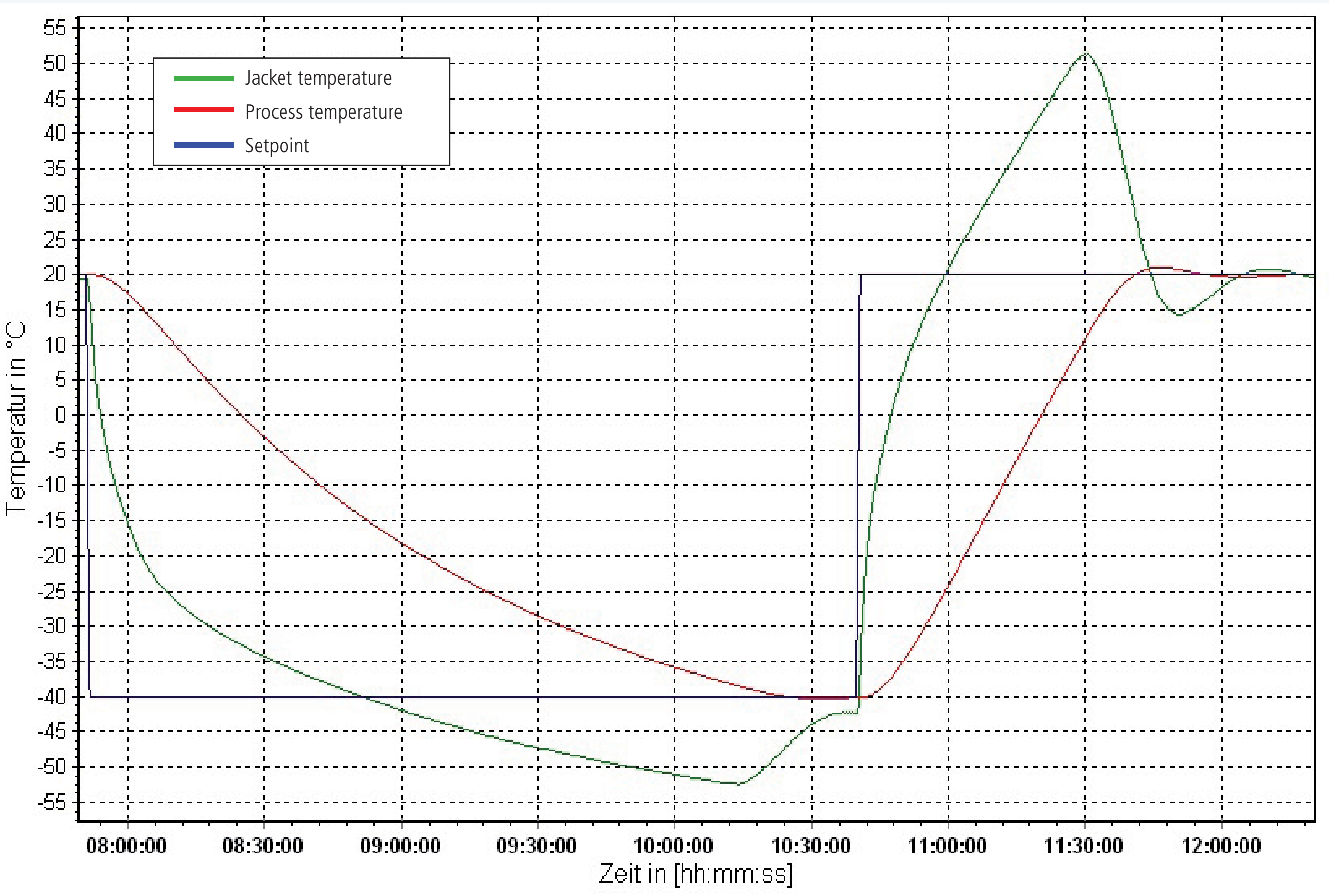
Unistat® 615w

Heating & cooling a 250-litre GLSS reactor through 60 K

Requirement
This case study shows the remarkable power transfer capabilities of the Unistat® range in using a Unistat® 615w to heat and cool a 250-litre Büchi GLSS reactor.

Method
The Unistat® was connected to the reactor using two 2-metre insulated metal hoses. The reactor was filled with 200 litre of Ethanol.

Results
The Unistat® cools the process from 20 °C to -40 °C (60 K) in approximately 150 minutes. It can be seen from the jacket temperature that the system is "comfortable" with this load. The heat up time back to 20 °C takes approximately 60 minutes.



Version: 9/2009

Unistat® 615w

Ramping a 250-litre Büchi GLSS reactor

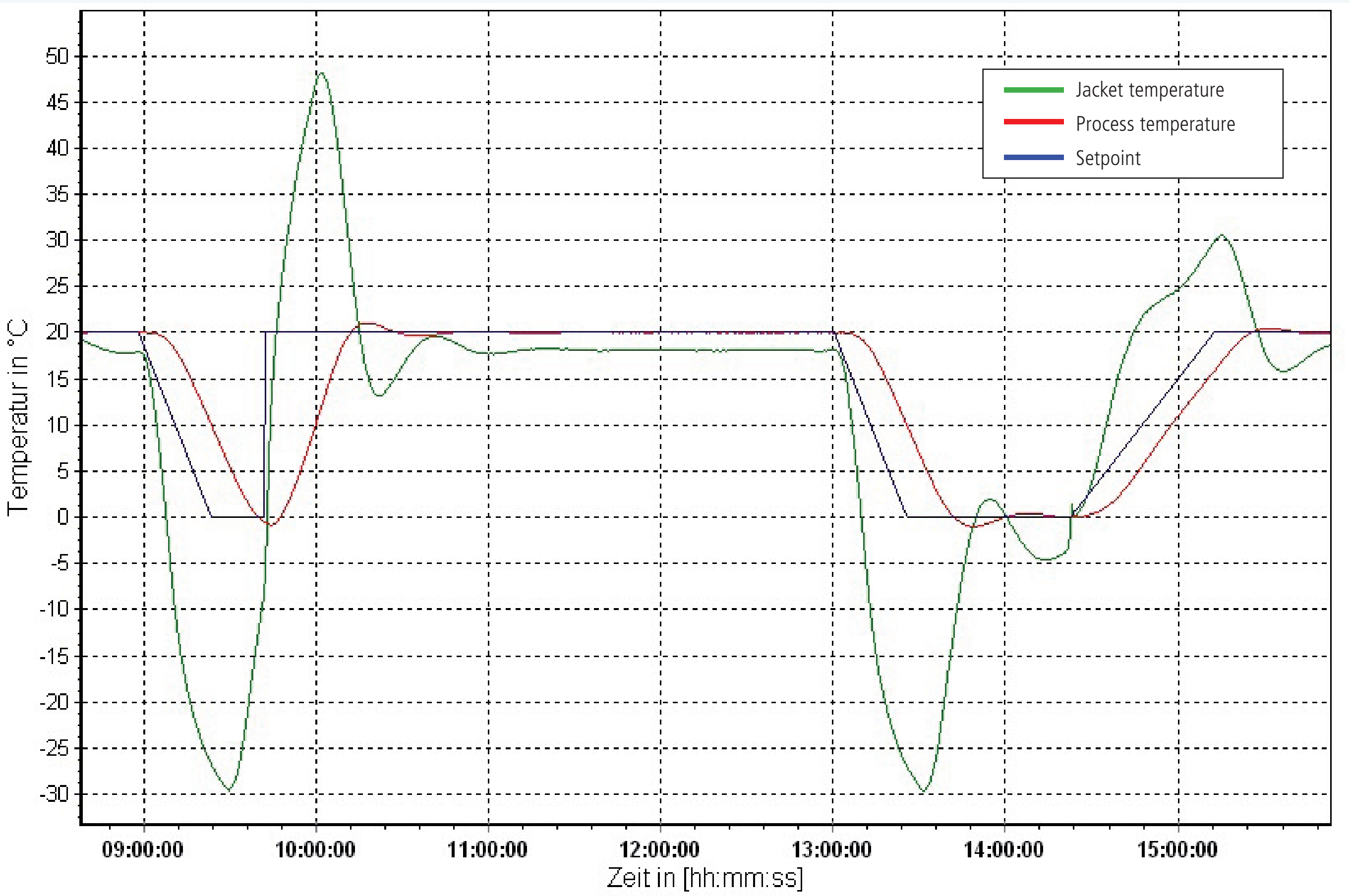
Requirement
This case study shows the remarkable power transfer capabilities of the Unistat® range in using a Unistat® 615w to heat and cool a 250-litre Büchi GLSS reactor.

Method
The Unistat® was connected to the reactor using two 2-metre insulated metal hoses. The reactor was filled with 200 litre of Ethanol.

Results
The closeness of control can be seen as the Unistat® ramps the process temperature between 20 °C to 0 °C and back at differing pre-programmed ramp rates.

Setup details

Temperature range:	–60...200 °C
Cooling power:	9.5 kW @ 200…0 °C 8.0 kW @ -20 °C 4.8 kW @ -40 °C 1.2 kW @ -60 °C
Heating power:	12 kW
Hoses:	M38x1,5; 2x2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre glass-lined (enameled) steel reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process



Version: 9/2009

Setup details

Temperature range:	–60...200 °C
Cooling power:	9.5 kW @ 200…0 °C
	8.0 kW @ -20 °C
	4.8 kW @ -40 °C
	1.2 kW @ -60 °C
Heating power:	12 kW
Hoses:	M38x1,5; 2x2 m
HTF:	DW-Therm
Reactor:	Büchi CR252
	250-litre glass-lined (enameled) steel reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process

Unistat® 615w

Heating & cooling a 250-litre GLSS reactor

Requirement

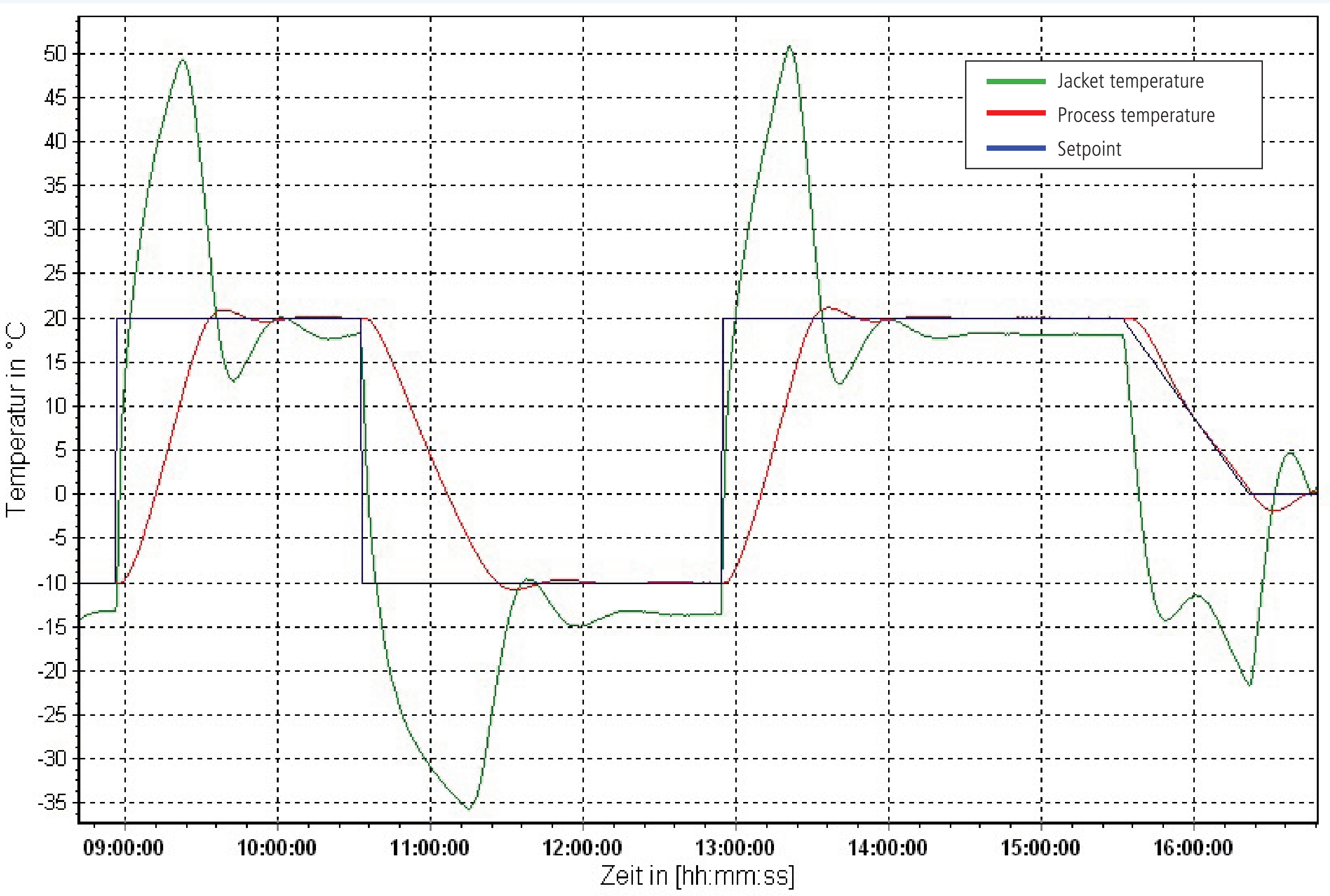
This case study shows the remarkable power transfer capabilities of the Unistat® range in using a Unistat® 615w to heat and cool a 250-litre Büchi GLSS reactor.

Method

The Unistat® was connected to the reactor using two 2-metre insulated metal hoses. The reactor was filled with 200 litre of Ethanol.

Results

The graph shows the close control and rapid response of the jacket to change the process temperature from 20 °C to -10 °C and back again. It takes approximately 60 minutes to cool the process through 30 K from 20 °C to -10 °C.



Version: 9/2009

Unistat® 620w

Heating and cooling Büchi CR101 100-litre reactor

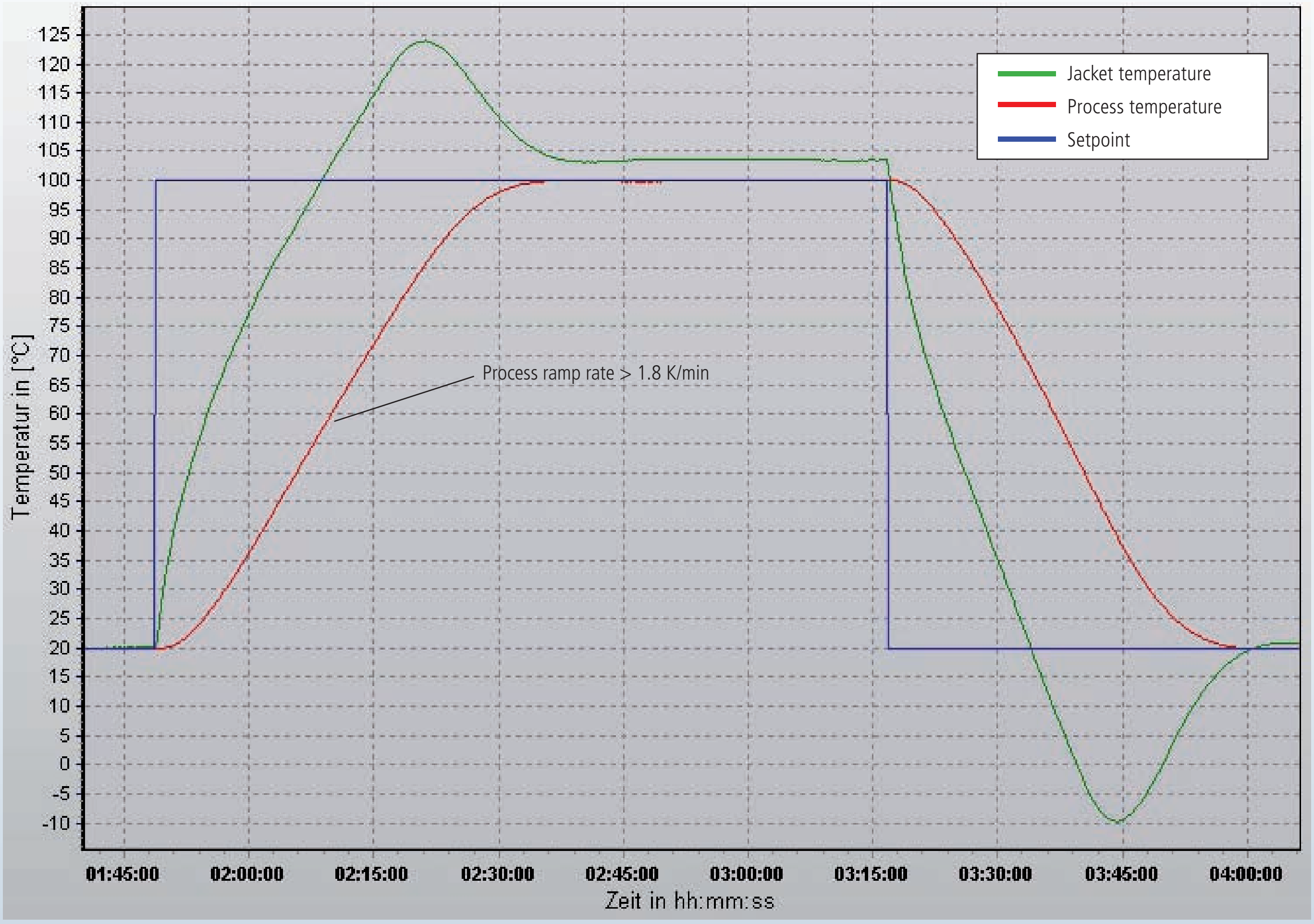
Requirement
This case study illustrates the performance curve of a Unistat® 620w connected to a Büchi 100-litre reactor with 2x1.5 m M38x1.5 hoses.

Method
The Unistat® and reactor were connected using two 1.5-metre hoses. The reactor was filled with 75-litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The "internal" (jacket) temperature ramps the process temperature to the set-points. The rapidly induced ΔT between jacket and process pulls the process temperature until it reaches the target temperature with negligible over/under shoot.
Once at target, the set-point is maintained in a highly stable manner.

Setup details
Unistat® 620w & Büchi 100-litre GLSS reactor

Temperature range:	-60...200 °C
Cooling power:	12.0 kW @ 200…-20 °C 6.5 kW @ -40 °C
Heating power:	12 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre jacketed glass reactor
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process



Version: 9/2009

Unistat® 705w

Constantly cryogenic sample management

Mecour & Huber have coupled their expertise to offer a new product designed specifically to hold and thermally manage samples at cryogenic temperatures to -100 °C with the ability to freeze and thaw the samples at a user specified strictly controlled rate.

The MeCour-Huber ultra-low temperature sample management systems are perfectly suited to laboratory benchtop or classified environments with a variety of accessories to integrate to existing automated platforms.

MeCour-Huber -60 °C benchtop sample management system.

MeCour-Huber ultra-low sample management systems will provide you with a powerful new tool minimizing adverse sample impact while increasing throughput. Whether you require a single or a hundred systems to provide temperature control to a few or dozens of samples, MeCour-Huber will work closely with you to provide the perfect solution(s) to meet your requirements.

Setup details

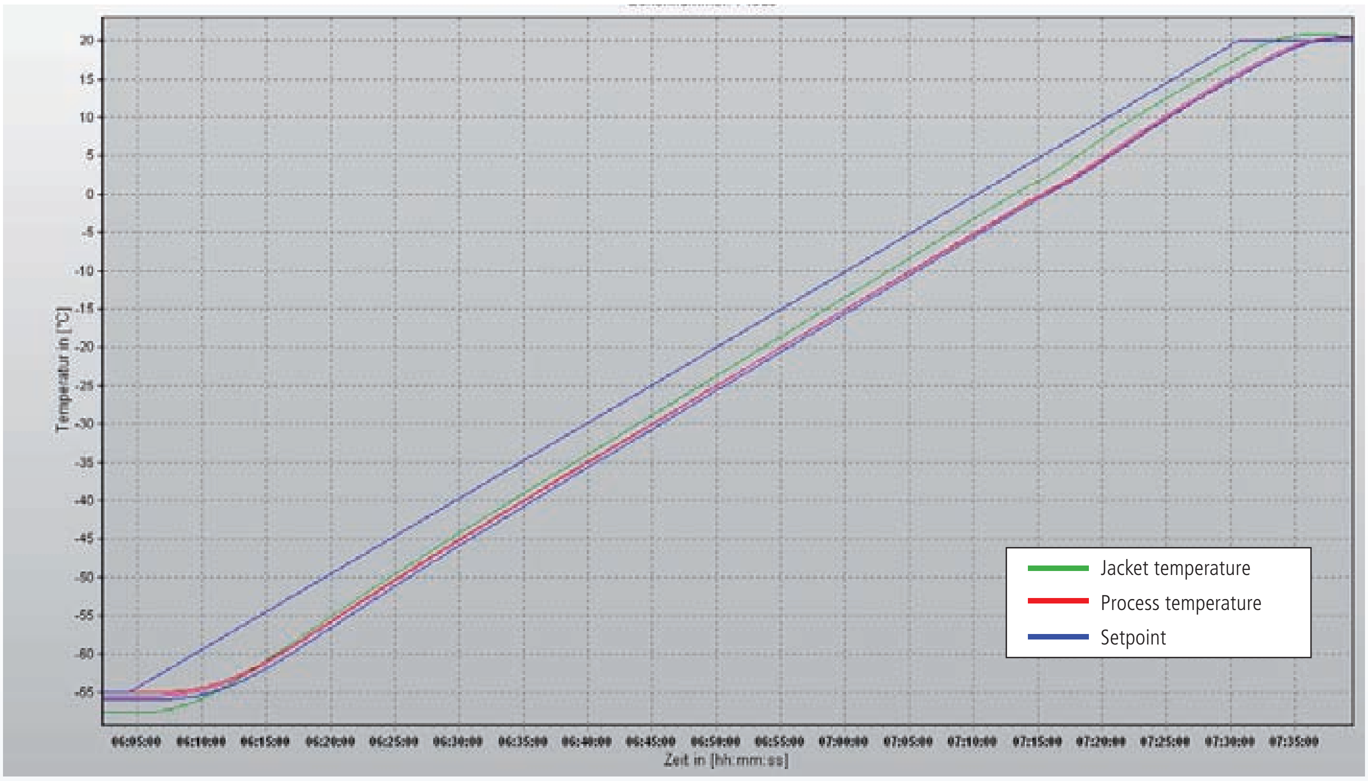
Unistat® 705w & MeCour ultra-low temperature sample management system

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C 0.65 kW @ 0 °C 0.6 kW @ -20...-40 °C 0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Application:	MeCour ultra-low temperature sample management system
Vials content:	24x1 ml Ethanol
Control:	process

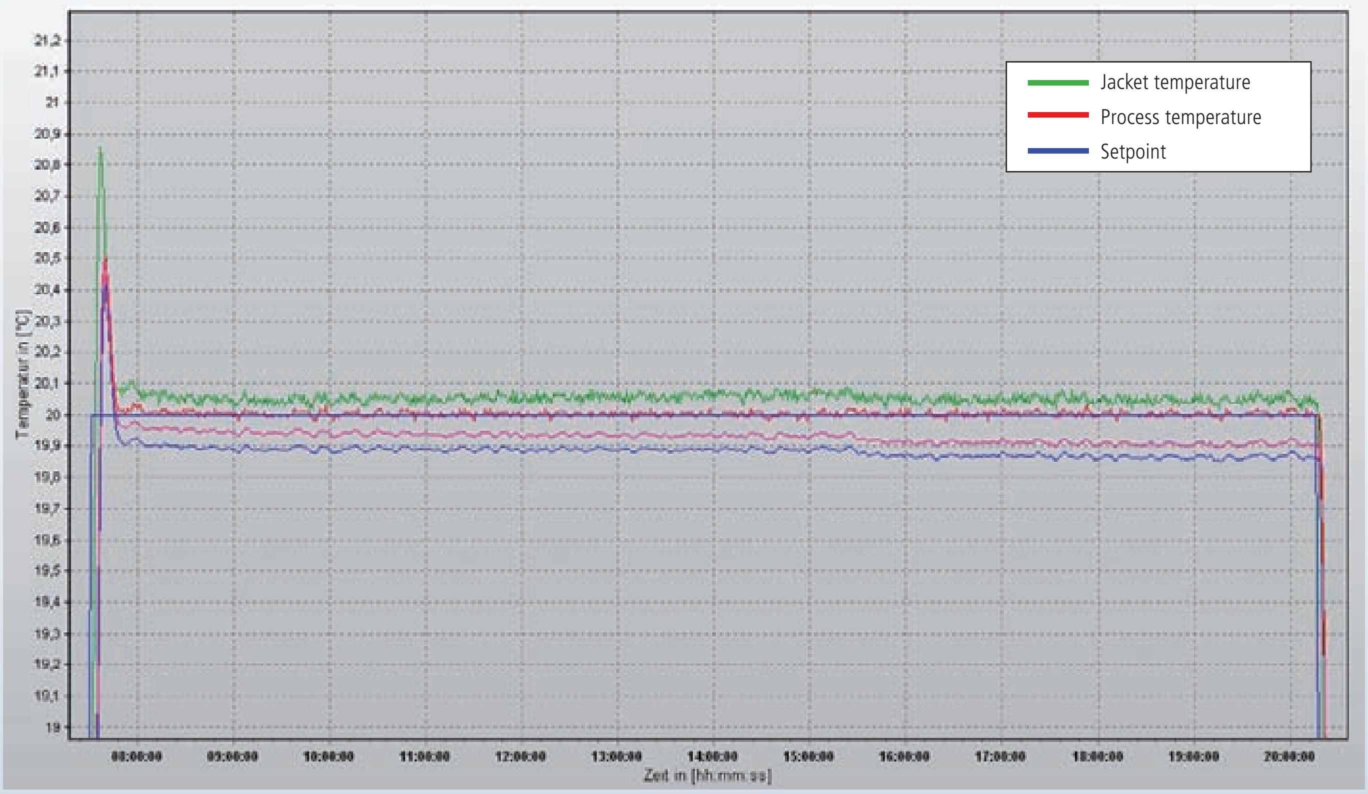
MeCour-Huber has designed systems with tolerances as tight as ± 0.1 °C. The MeCour-Huber ultra-low temperature cryostats are specifically designed to eliminate "edge-effect" and hot/cold spots ensuring precise and accurate temperature distribution across the working areas of the system. The superior performance of these thermal systems has been validated through a number of thermal mapping studies. Results of this testing under both static and ramping conditions are presented in the following figures.

Version: 9/2009

The following thermal mapping data demonstrates the superior precision and stability of the MeCour-Huber ultra-low thermal management systems. More data is available on request.



Thermal mapping study on MeCour-Huber ultra-low sample management system with a specified tolerance of ± 1 °C under controlled ramping conditions, ambient to -65 °C



Thermal mapping study on MeCour-Huber ultra-low sample management system with a specified tolerance of ± 0.1 °C under static conditions at 20 °C

Setup details

Unistat® 705w & Büchi reactor Ecoclave (büchiglasuster)

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW/3 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre jacketed glass pressure reactor
Reactor content:	0.75 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

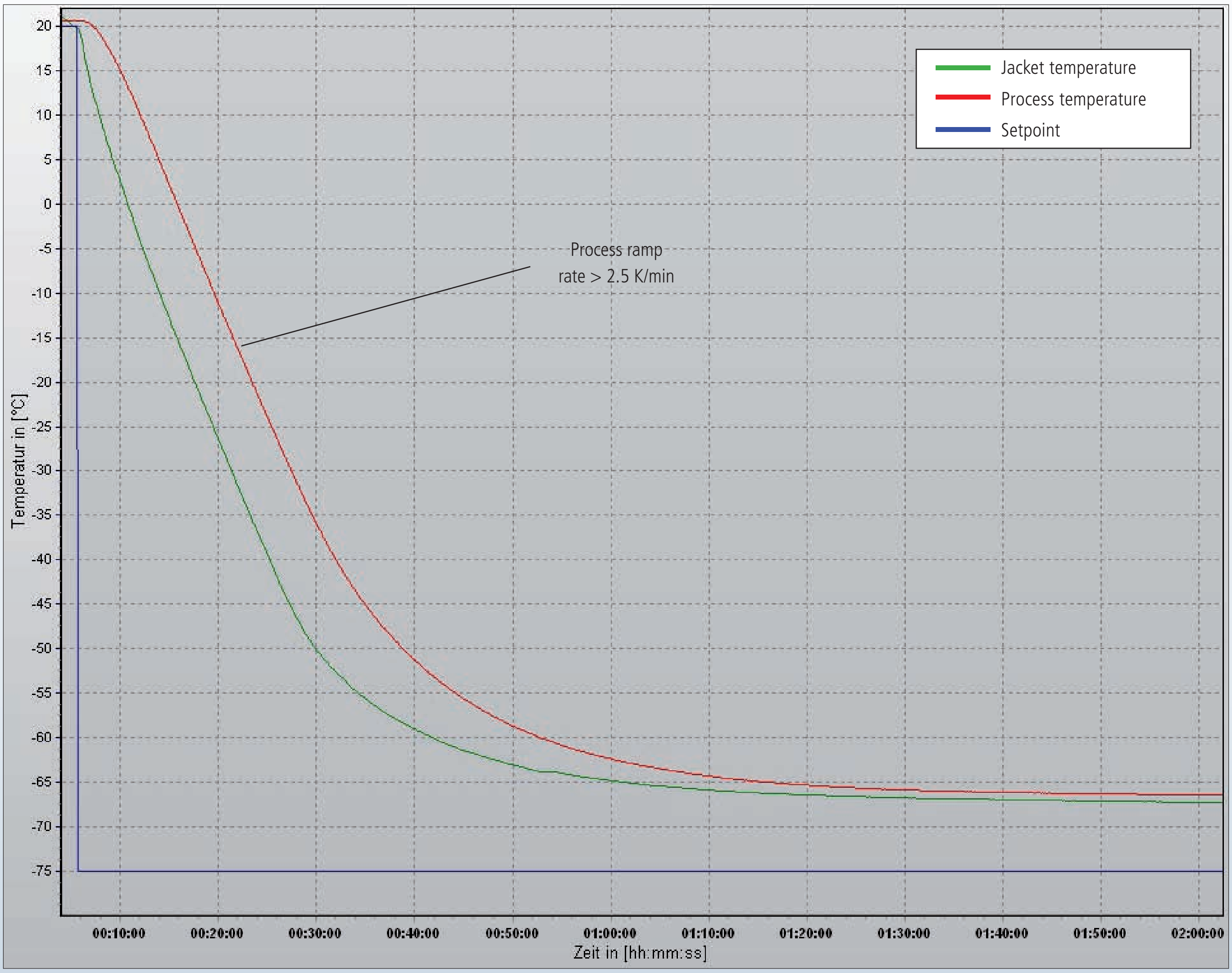
Unistat® 705w

1-litre Büchi reactor from 20 °C to "T_{min}"

Requirement
The purpose of this test is to demonstrate the minimum achievable process temperature in a 1-litre jacketed glass pressure reactor when connected to a Unistat® 705w.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The graphic shows the process temperature beginning to asymptote at -50 °C. The jacket temperature reaches a minimum of -67 °C with a minium process temperature of -66 °C.



Unistat® 705w

Heating and cooling a DDPS 2-litre jacketed reactor

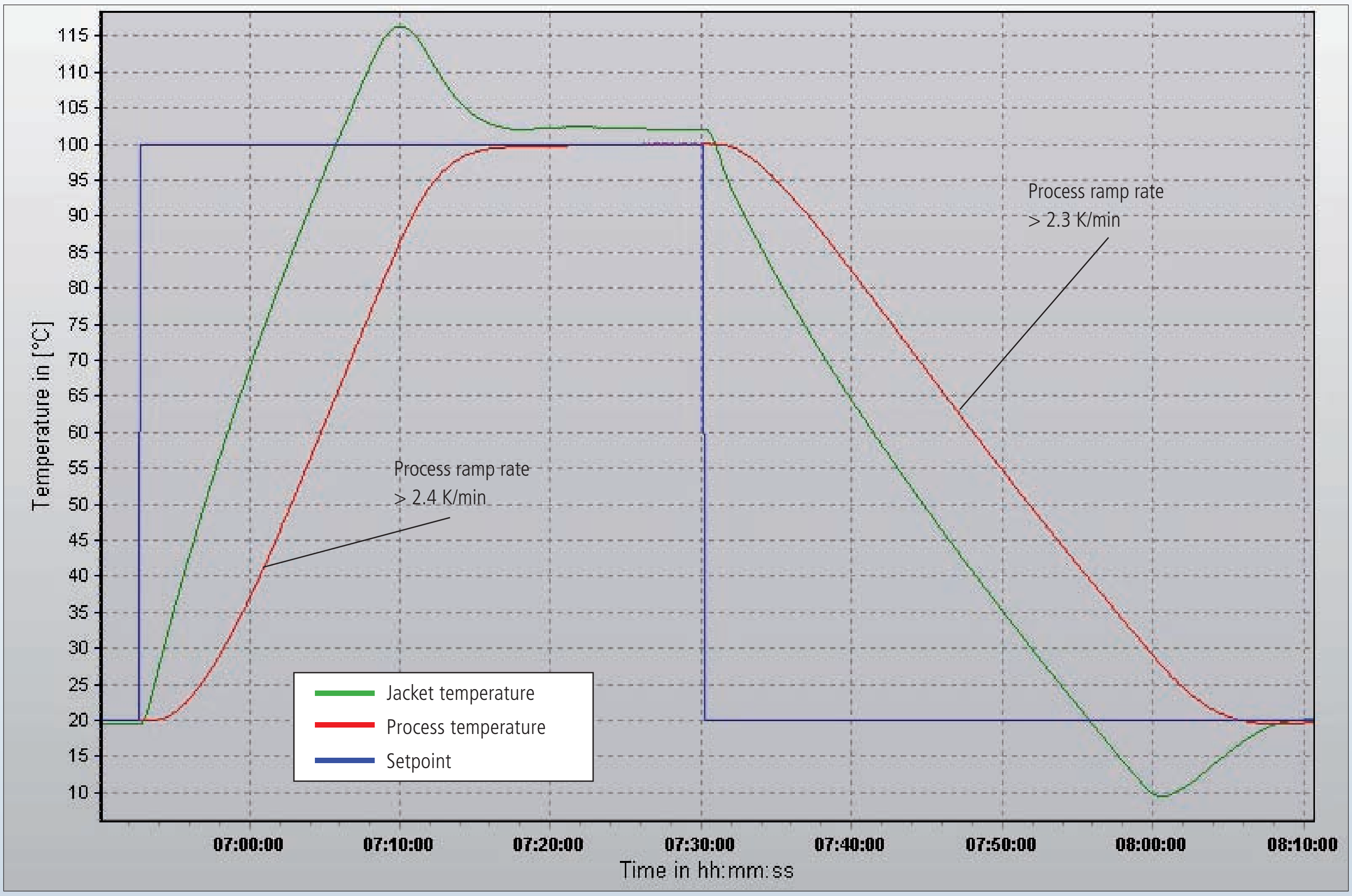
Requirement
The purpose of this case study is to demonstrate the performance of a Unistat® 705w in heating and cooling a 2-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 1.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Result
The resulting curve shows it takes 33 minutes to heat from 20 °C to 100 °C giving a heating ramp-rate of 2.4 K / min.
In cooling, the curve shows the process takes 35 minutes to reach 20 °C giving a cooling ramp-rate of 2.3 K / min.

Setup details
Unistat® 705w & 2-litre DDPS reactor

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C 0.65 kW @ 0 °C 0.6 kW @ -20...-40 °C 0.3 kW @ -60 °C
Heating power:	1.5 kW/3 kW (in this test limited to 1.0 kW)
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre un-insulated jacketed glass reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C 0.65 kW @ 0 °C 0.6 kW @ -20...-40 °C 0.3 kW @ -60 °C
Heating power:	1.5 kW/3 kW
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	3 litre un-insulated metal pressure reactor
Reactor content:	2.25 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

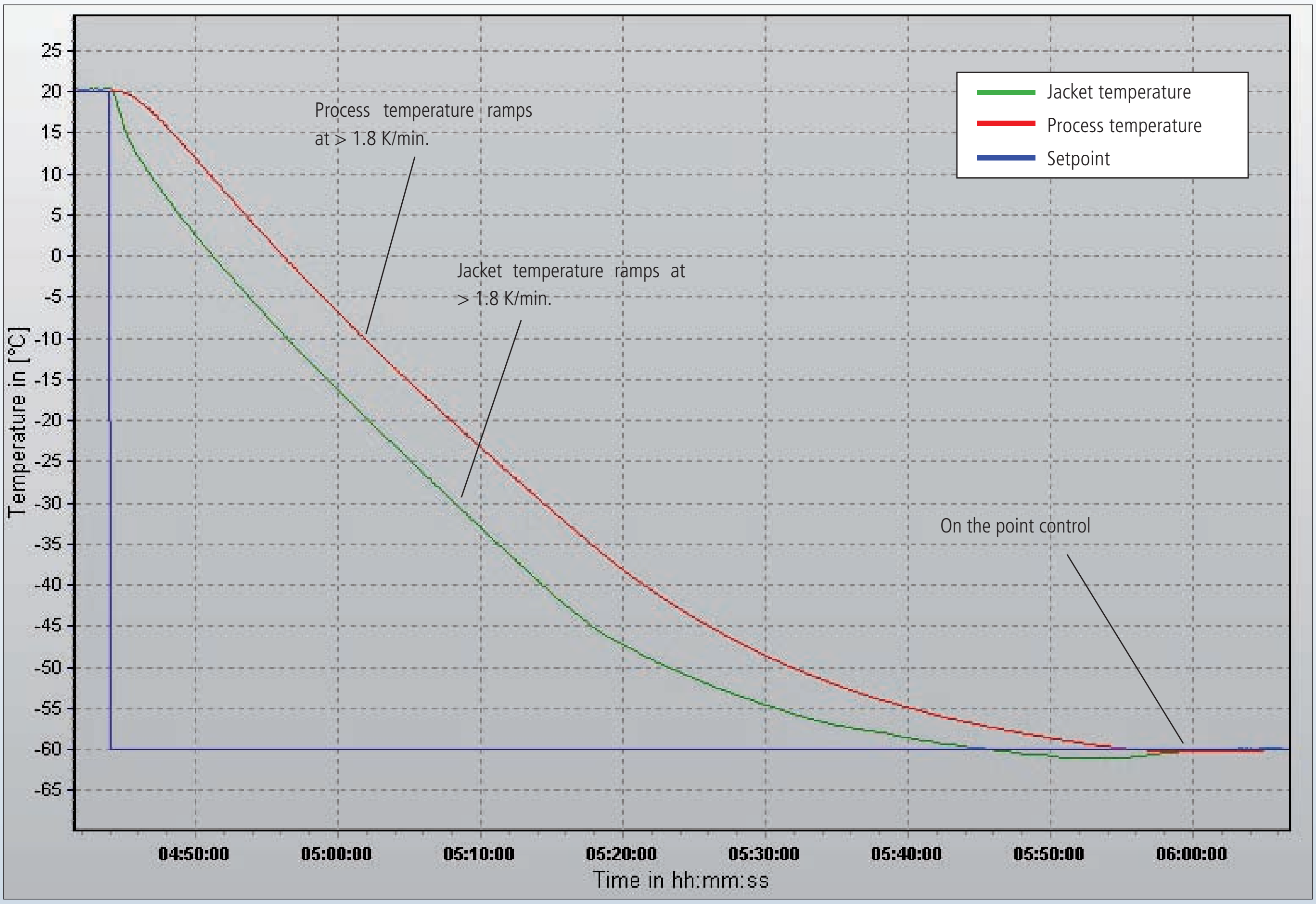
Unistat® 705w

Cooling a Büchi 3-litre reactor to -60 °C

Requirement
The graphic illustrates the performance of a Unistat® 705w cooling a 3-litre un-insulated metal pressure reactor from 20 °C to -60 °C.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 2.25 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The "internal" (jacket) temperature cools at an average ramp rate of 1.8 K / min. The process temperature ramps down at > 1.8 K / min. This process cools through 80 K (20 °C to -60 °C) in 74 minutes.



Version: 9/2009

Unistat® 705w

Effects of differing control dynamics when heating and cooling a Büchi 3-litre metal jacketed reactor

Requirement

Every Unistat® can be set to ramp "Fast with small over shoot" or "No overshoot".This case study looks at the response of a Unistat® 705w under different "control dynamics"

Method

The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 2.25 litre of "M90.055.03", a Huber supplied silicon based HTF.

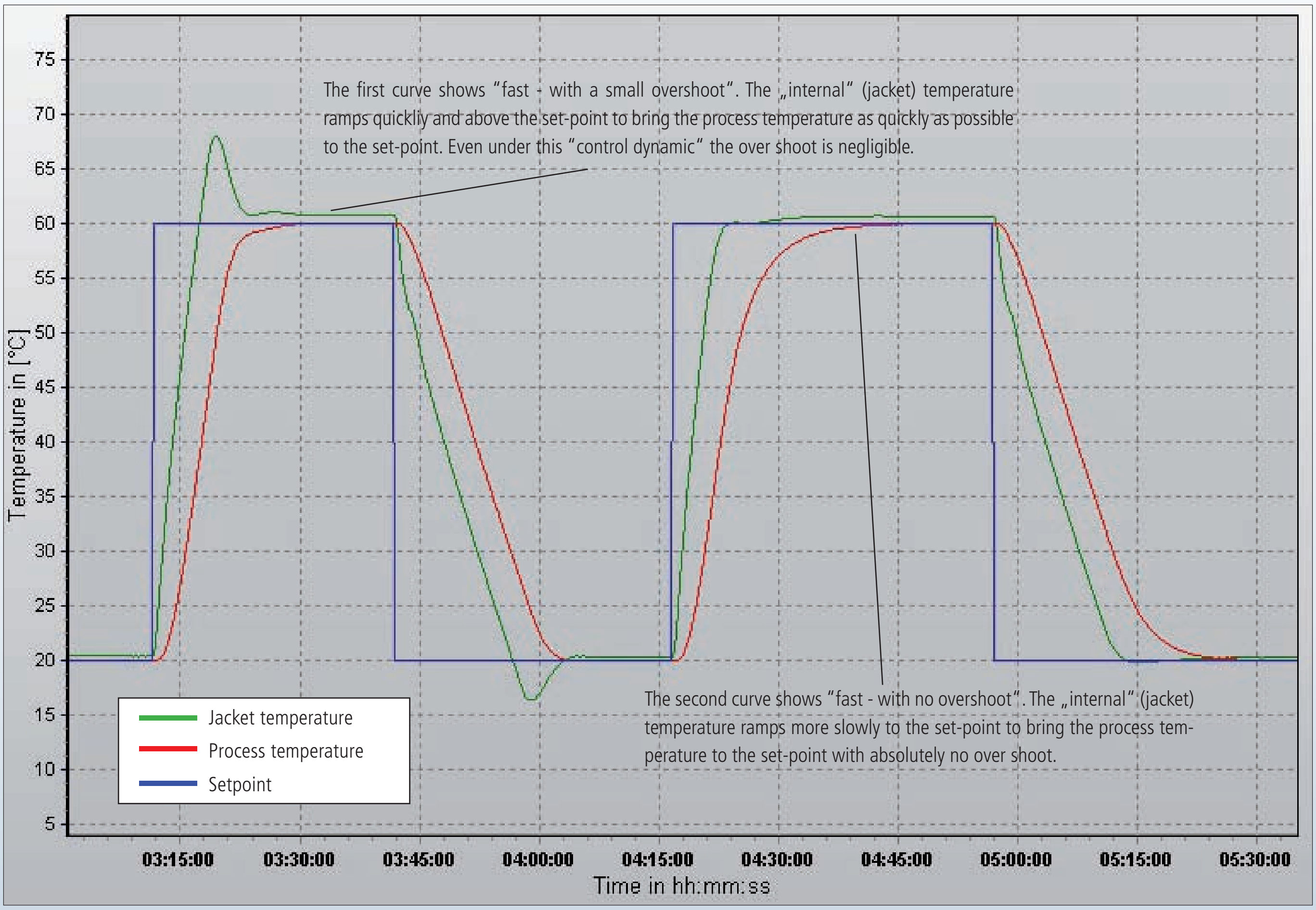
Results

The first curve is under "Fast with small over shoot" , even so it can be seen that after ramping rapidly through 40 K (20 °C to 60 °C) in approximately 15 minutes, the process temperature hits exactly the set-point with NO over shoot. The second curve is carried out under the "No overshoot dynamic setting.

Setup details

Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75…250 °C
Cooling Power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW/3 kW
Pump speed	3500 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	3 litre un-insulated metal pressure reactor
Reactor contents:	2.25 litre M90.055.03 (#6259)
Reactor stirrer speed	200 rpm
Control:	process



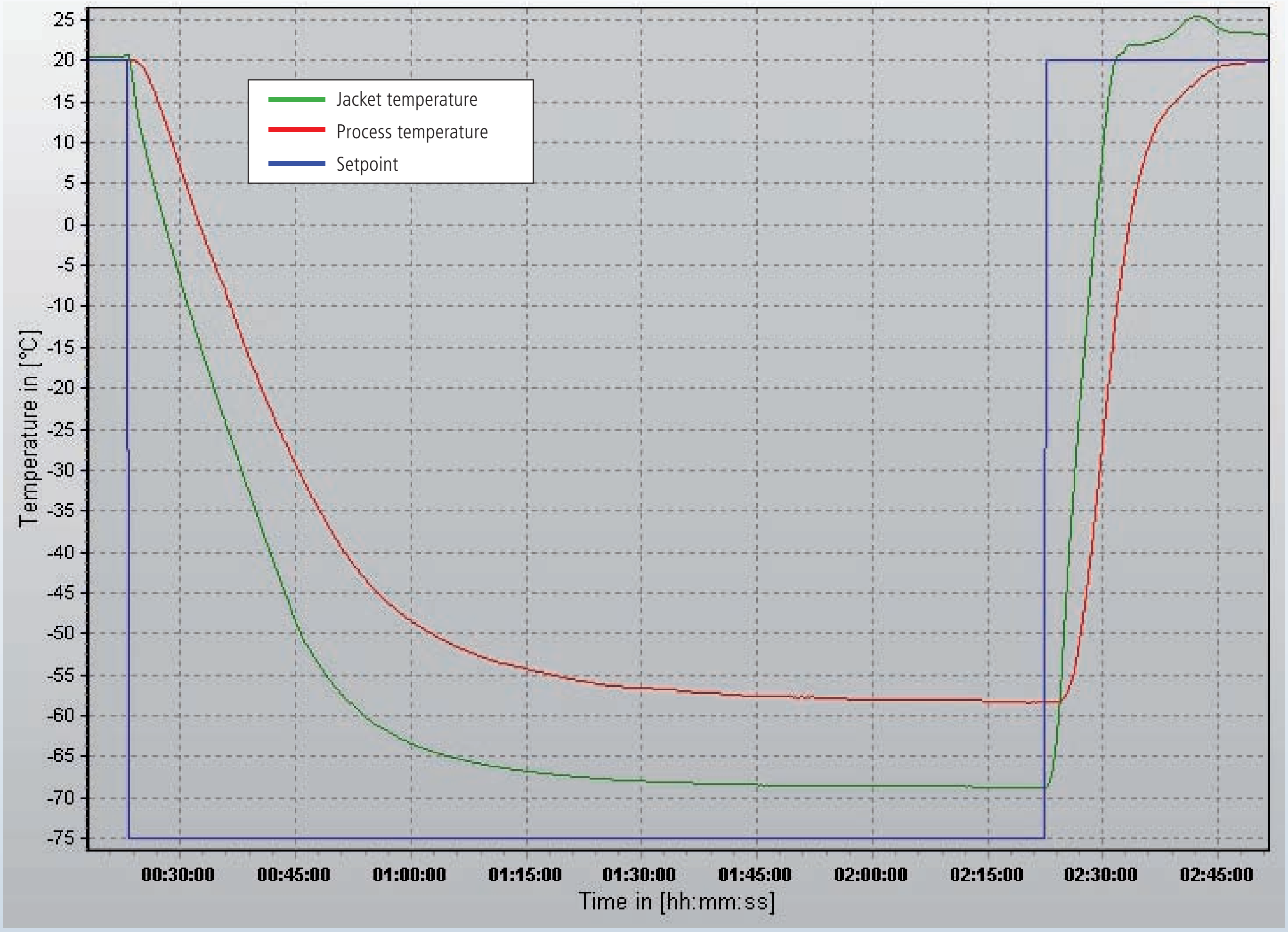
Version: 9/2009

Unistat 705w

in combination with a Heidolph Synthesis 1

Requirement
What you see is what you get:
The goal of this case study is to show if a temperature of -50 °C inside the test tubes can be reached and how much time will be needed.
The second part of this case study shall show the performance including the Heidolph Synthesis 1 temperature control.
There is a built-in heater with four temperature probes inside the Heidloph Synthesis 1.

Method
The Unistat® 705w (a hydraulically sealed sytem) was used for thermoregulation.
The Unistat® 705w has a temperature range of -75 °C until 250 °C and a cooling power of 650 W at 0 °C.
As can be seen on the first graph below, the red „process" temperature measured inside a test tube with a Pt 100 reached -50 °C in about 40 min, the lowest temperature of -58 °C was reached within a total of 92 min.
Heating back up to 20 °C will take about 23 min.



Version: 9/2009

Unistat® 705w

The next test was conducted with the built-in heater of the Heidolph Synthesis 1 being switched on at 20 °C. The setpoints of all four temperature zones of the Synthesis 1 were set at -30 °C and then reduced to -50 °C.
The setpoint of -30 °C was reached after about 32 min. The setpoint of -50 °C was reached after additional 23 min. At both setpoints the process temperature offset was due to the postion of the Pt 100.

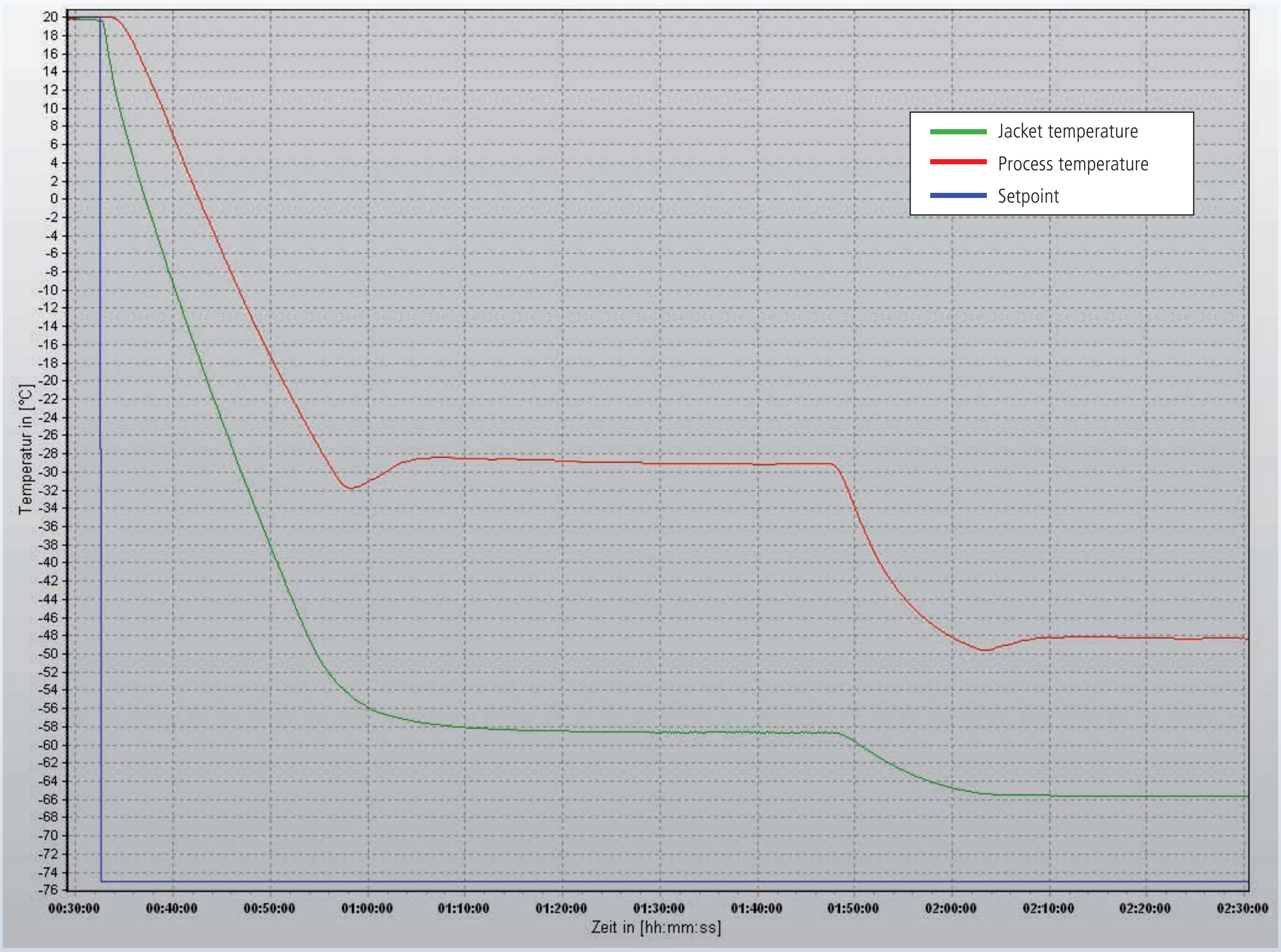
Results
In comparsion to previously published case study with the Heidolph Synthesis 1 it is possible to achieve lower temperature with less cooling power and in a much faster time.
The initial cost of the complete system with an Unistat® 705w and the Heidolph Synthesis 1 are about 30 % lower than the setup mentioned in the previously published case study.

Setup details
Unistat® 705w with optional bypass installed

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW (3 kW @ 400 V)
Pump speed:	3500 rpm
Hoses:	2 x1 m M24 x 1,5 #9325
HTF:	Ethanol
Reactor:	Heidolph Synthesis 1
Control:	process (inside test tube)
Control of the Heidolph Synthesis 1:	off

Setup details: Heidolph Synthesis 1
Each of the 24 test tubes of the Synthesis 1 were filled with 5 ml Sil Oil Huber M90.055.03 #6259

Control of the Heidolph Synthesis 1:	Zone temperatures via internal sensors.
Setpoint 1:	-30 °C
Setpoint 2:	-50 °C



Setup details
Unistat® 705w & Radley reactor

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250 °C…100 °C 0.65 kW @ 0 °C 0.6 kW @ -20...-40 °C 0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre un-insulated jacketed glass reactor
Reactor content:	0.75 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

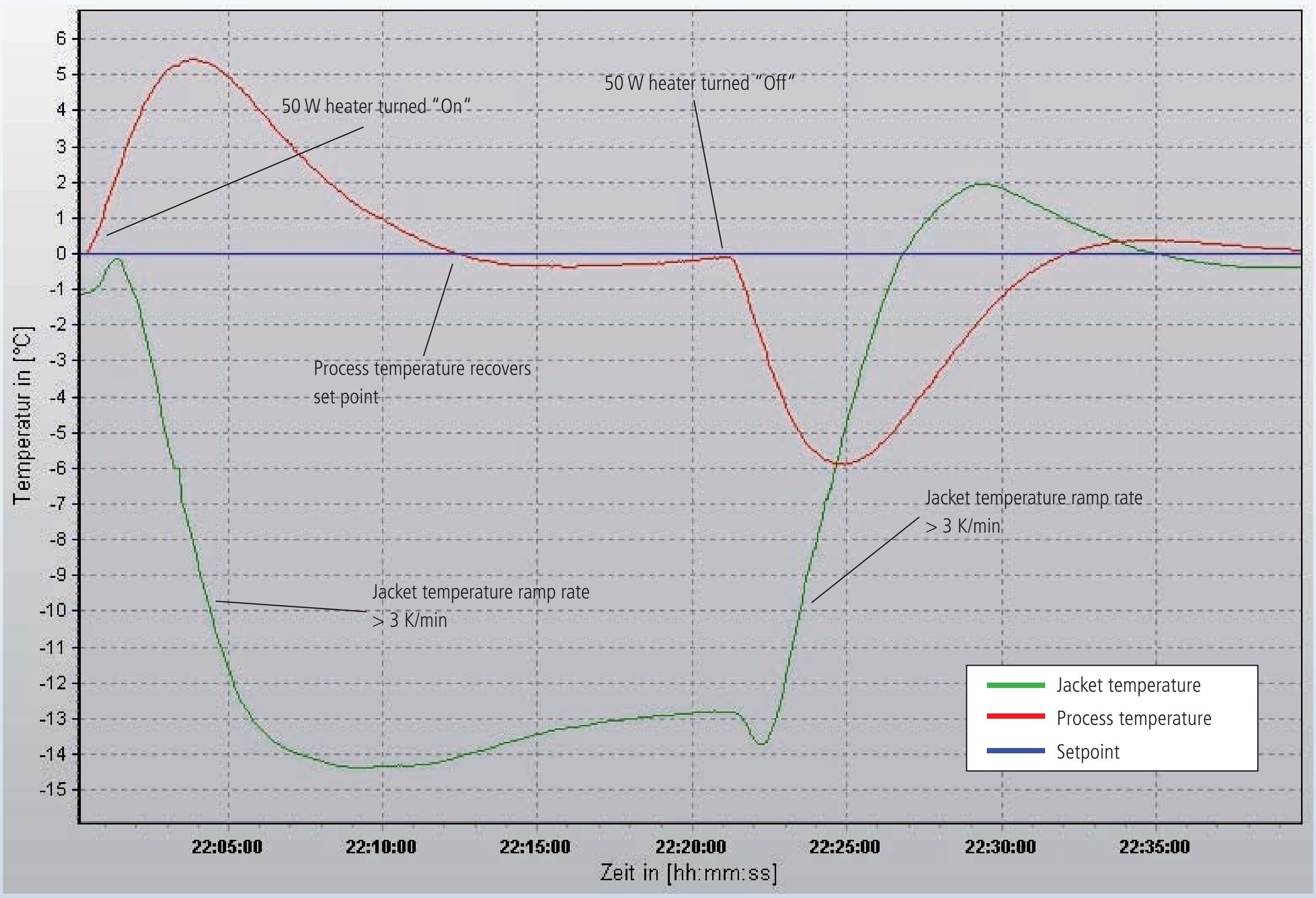
Unistat® 705w

50 W (43 kcal / hr) exothermic reaction in a Radleys 1-litre glass reactor

Requirement
The diagram illustrates the performance of a Unistat® 705w working with a Radleys 1-litre un-insulated jacketed glass reactor. An exothermic reaction of 50 W (43 kcal / hr) is simulated at a temperature of 0 °C.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process temperature rises 5.5 °C above the set-point from the heat of the simulated exothermic reaction. The Unistat® 705w reacts to this change of temperature by cooling the jacket rapidly to approximately -14.5 °C pulling the process temperature back to 0 °C.
When the exothermic reaction stops the process temperature undershoots to -6 °C before the jacket temperature is rapidly ramped upwards to return the process to its set-point.



Version: 9/2009

Unistat® 705w

Heating a Radleys 1-litre jacketed glass reactor from 20 °C to 100 °C

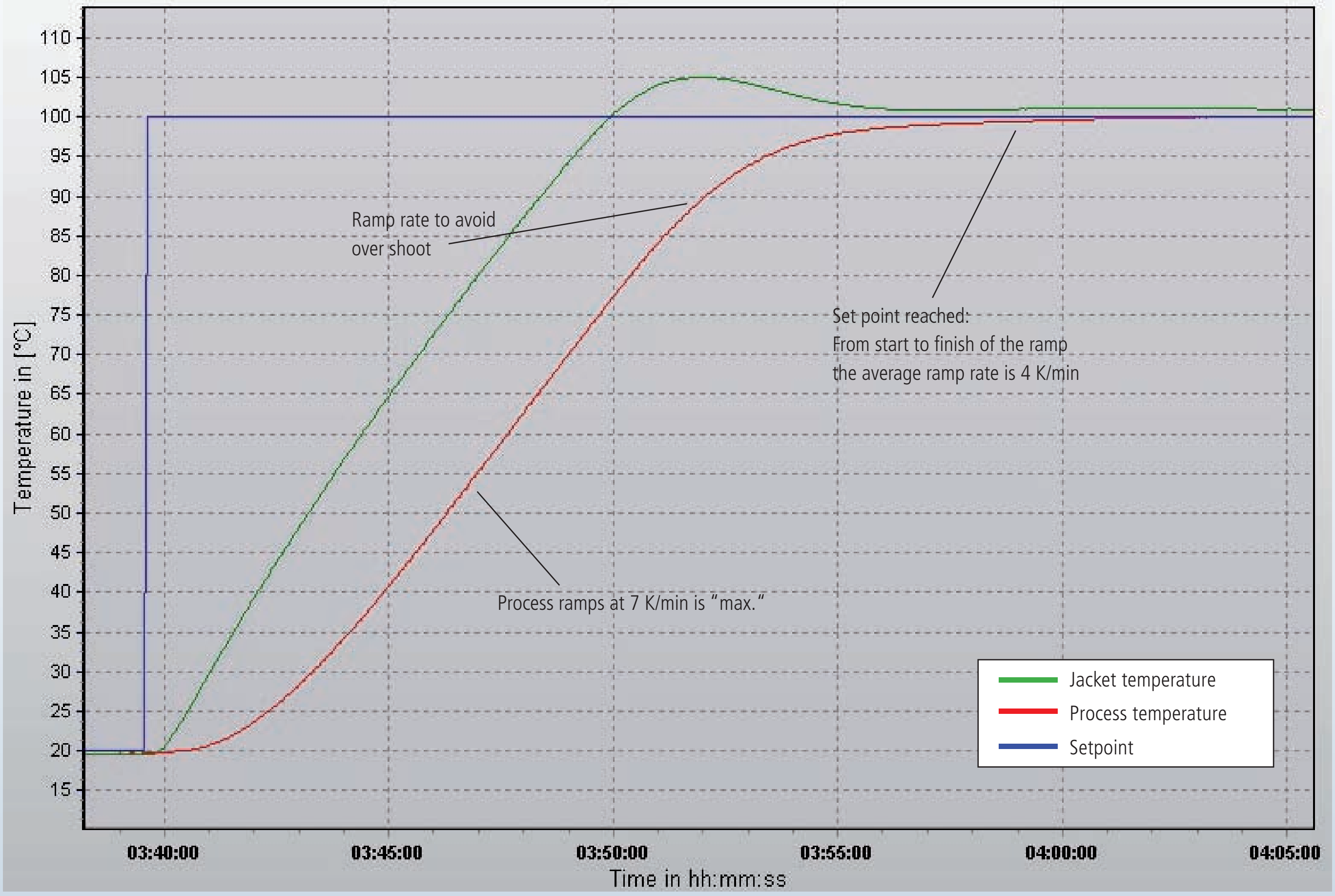
Requirement
This case study looks at the performance of a Unistat® 705w heating a Radleys 1-litre glass reactor from 20 °C to 100 °C under "process" control.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The control dynamic is set to "no overshoot" so the final approach to the set-point is slower to ensure that the process does not overshoot its target temperature.
Even with this dynamic set it can be seen in the graphic the speed of the ramp to the set-point.

Setup details
Unistat® 705w & Radleys reactor

Temperature range:	-75…250 °C
Cooling Power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre un-insulated jacketed glass reactor
Reactor contents:	0.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 705w & Radleys reactor

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C 0.65 kW @ 0 °C 0.6 kW @ -20...-40 °C 0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre un-insulated jacketed glass pressure reactor
Reactor content:	0.75 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

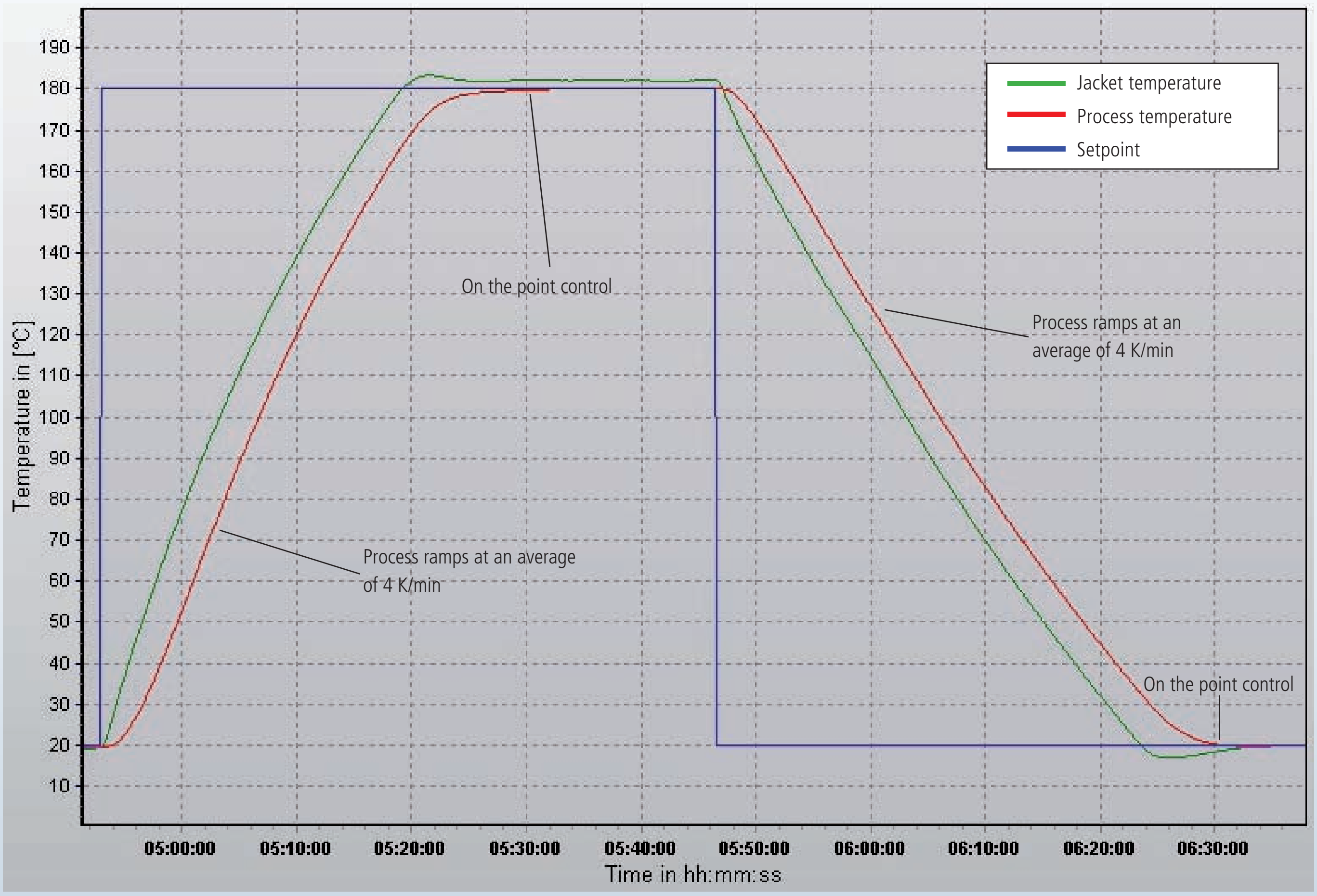
Unistat® 705w

Heating & cooling a 1-litre jacketed glass reactor from 20 °C to 180 °C and back to 20 °C

Requirement
This case study looks at the performance of a Unistat® 705w heating and cooling a Radleys 1-litre un-insulated jacketed glass pressure reactor from 20 °C to 180 °C and back to 20 °C under "process" control.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
On the heating curve the process ramps through 160 K (20 °C to 180 °C) within 40 minutes (ramp rate of 4 K / min). The process also ramps back through 160 K (180 °C to 20 °C) within 40 minutes (ramp rate 4 K / min).



Version: 9/2009

Technical details and dimensions are subject to change. No liability is accepted for errors or ommisions.

Unistat® 705w

Heating a Büchi 1-litre reactor from 20 °C to 180 °C

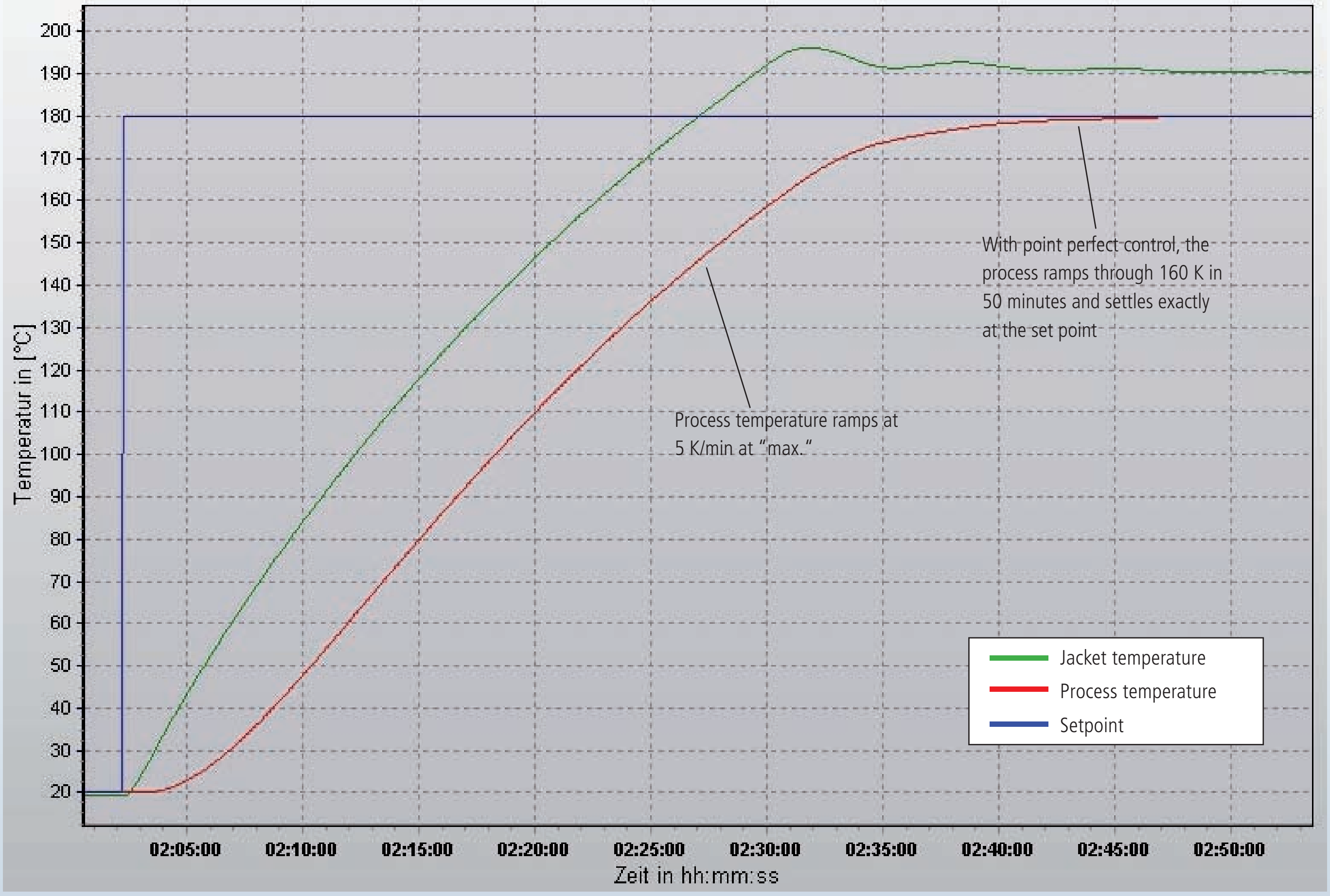
Requirement
The heating curve shows the performance of a Unistat® 705w heating a 1-litre reactor from 20 °C to 180 °C.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process temperature rapidly ramps through 180 °C in 50 minutes to reach the required temperature. It represents a heating ramp rate of 3.2 K / min.
It can be clearly seen how the process curve reaches 180 °C without over shooting the set-point.

Setup details
Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75…250 °C
Cooling Power:	0.6 kW @ 250…100 °C 0.65 kW @ 0 °C 0.6 kW @ -20...-40 °C 0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre un-insulated jacketed glass pressure reactor
Reactor contents:	0.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	500 rpm
Control:	process



Version: 9/2009

Technical details and dimensions are subject to change. No liability is accepted for errors or ommisions.

Setup details
Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C 0.65 kW @ 0 °C 0.6 kW @ -20...-40 °C 0.3 kW @ -60 °C
Heating power:	1.5 kW/3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	1 litre un-insulated jacketed glass pressure reactor
Reactor content:	0.75 litre M90.055.03 (#6259)
Stirrer speed:	500 rpm
Control:	process

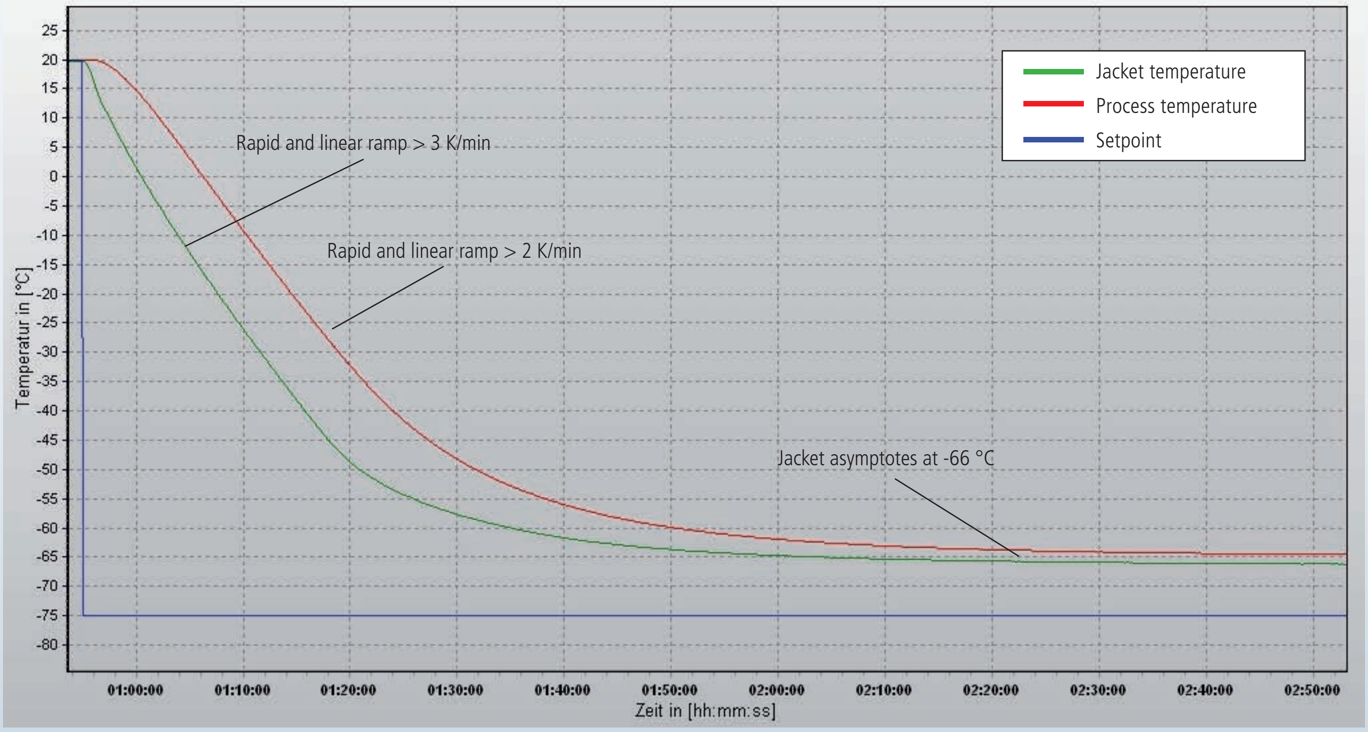
Unistat® 705w

Cooling a Büchi 1-litre reactor to T_{min}

Requirement
This case study looks at the performance of a Unistat® 705w cooling a Büchi 1-litre un-insulated jacketed glass pressure reactor to T_{min} under "process" control.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 0.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The jacket cooling curve is almost linear to -50 °C where it begins to asymptote before reaching its lowest temperature of -66 °C with a corresponding process temperature of -65 °C.



Unistat® 705w

Heating & cooling a DDPS 2-litre glass reactor

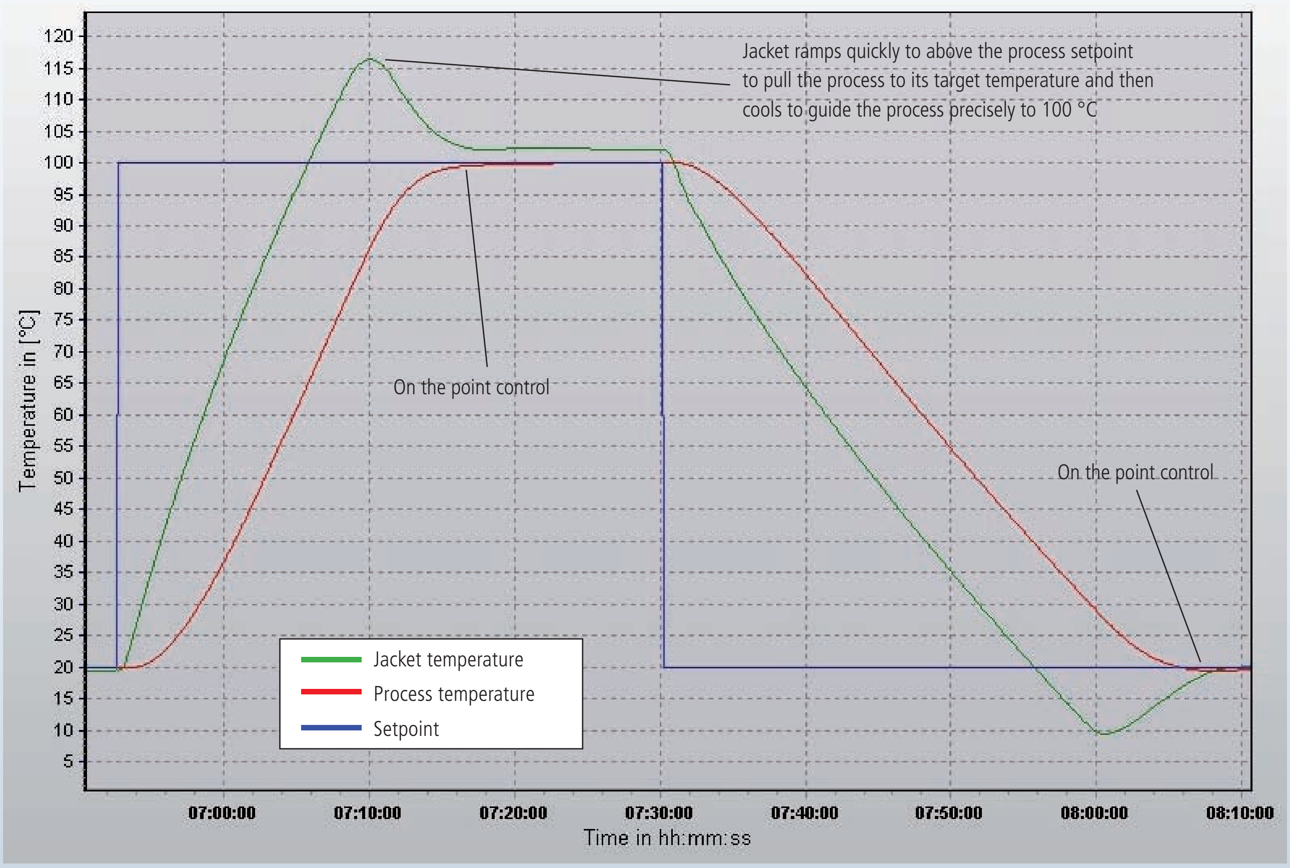
Requirement
This case study looks at the performance of a Unistat® 705w heating and cooling a DDPS 2-litre jacketed glass reactor from 20 °C to 100 °C and back under "process" control.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 1.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process is ramped from 20 °C to 100 °C (80 K) within 20 minutes (ramp rate > 4 K / min) and cooled at a ramp rate > 2.1 K / min.

Setup details
Unistat® 705w & DDPS reactor

Temperature range:	-75…250 °C
Cooling Power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	2 litre jacketed glass reactor
Reactor contents:	1.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 705w & DDPS reactor

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3300 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	DDPS 2 litre un-insulated jacketed glass reactor
Reactor content:	1.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

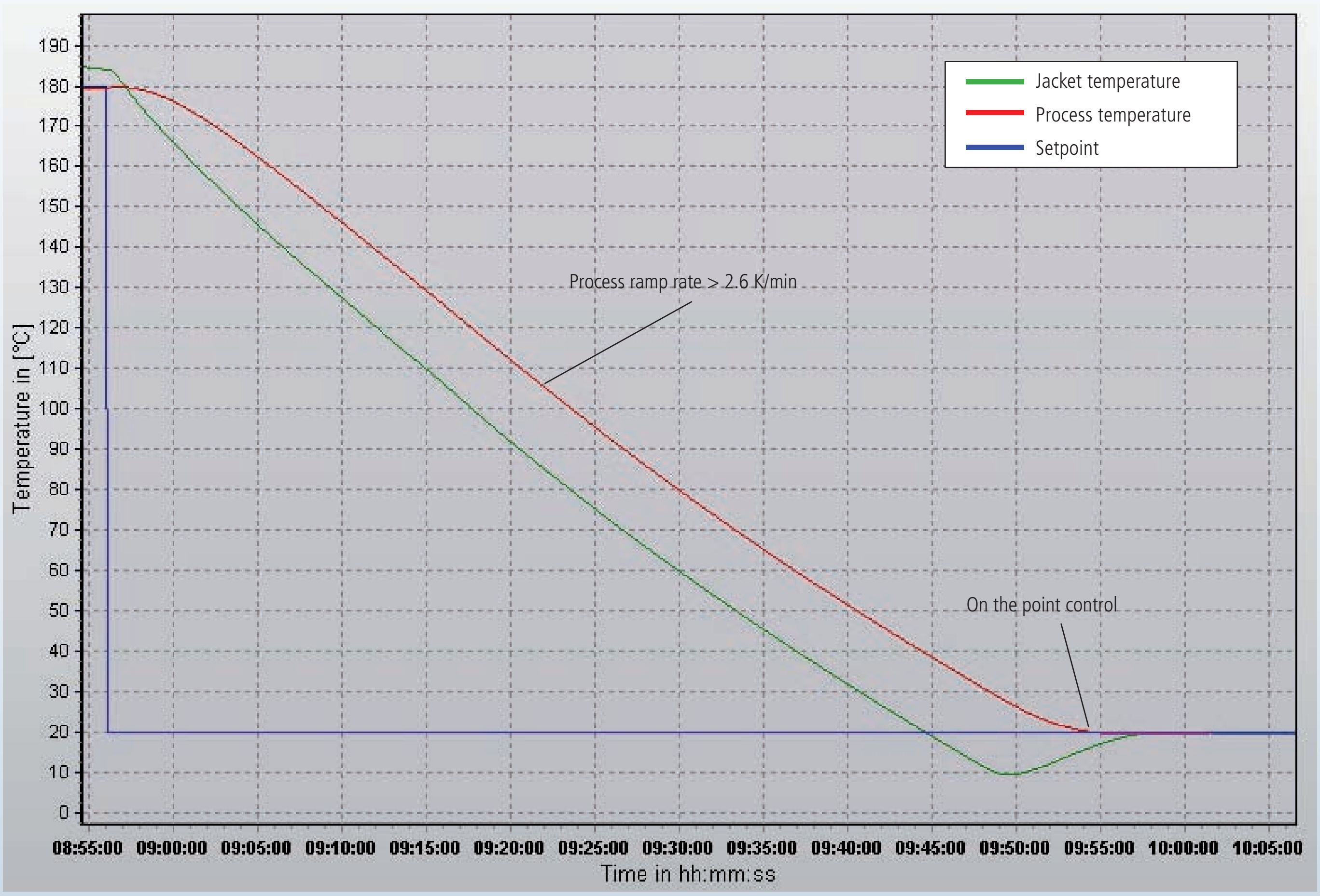
Unistat® 705w

Cooling a 2-litre jacketed glass reactor to 20 °C from 180 °C

Requirement
This case study looks at the performance of a Unistat® 705w cooling a 2-litre glass reactor from 180 °C to 20 °C under "process" control.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 1.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process is ramped from 180 °C to 20 °C (160 K) within 60 minutes (ramp rate > 2.6 K / min).



Version: 9/2009

Unistat® 705w

Cooling a Büchi 3-litre metal reactor to T_{min}

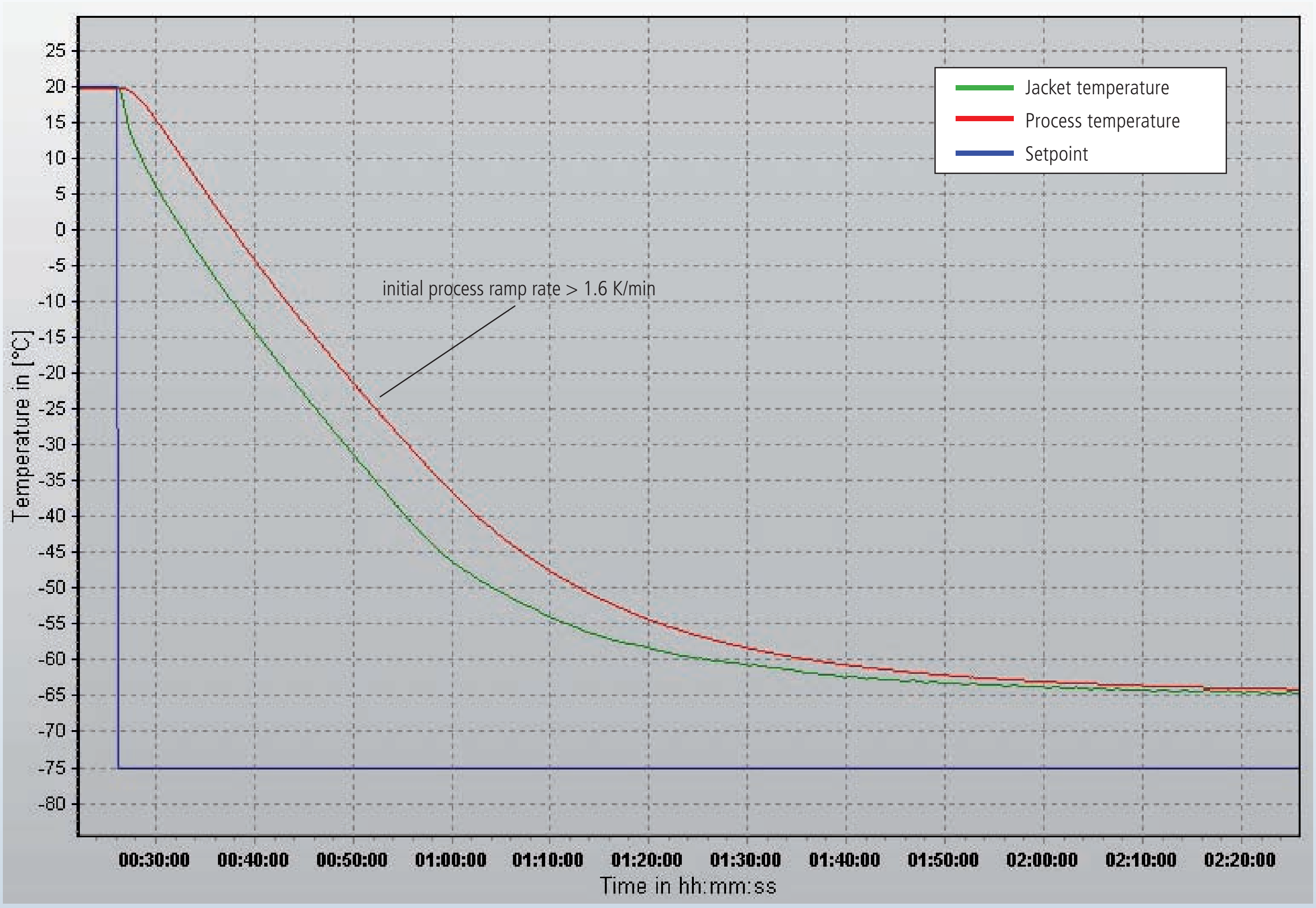
Requirement
This study looks at the minimum achievable temperature of a Unistat® 705w connected to a Büchi 3-litre un-insulated metal pressure reactor under "internal" control.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 2.25 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
After 2 hours the cooling power asymptotes at an internal temperature of -65 °C with a corresponding process temperature of -63 °C.

Setup details
Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75…250 °C
Cooling Power:	0.6 kW @ 250…-40 °C 0.3 kW @ -60 °C
Heating Power:	1.5 kW / 3 kW
Pump speed	3500 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	3 litre un-insulated metal pressure reactor
Reactor contents:	2.25 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	internal



Setup details
Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3500 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	3 litre un-insulated metal pressure reactor
Reactor content:	2.25 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

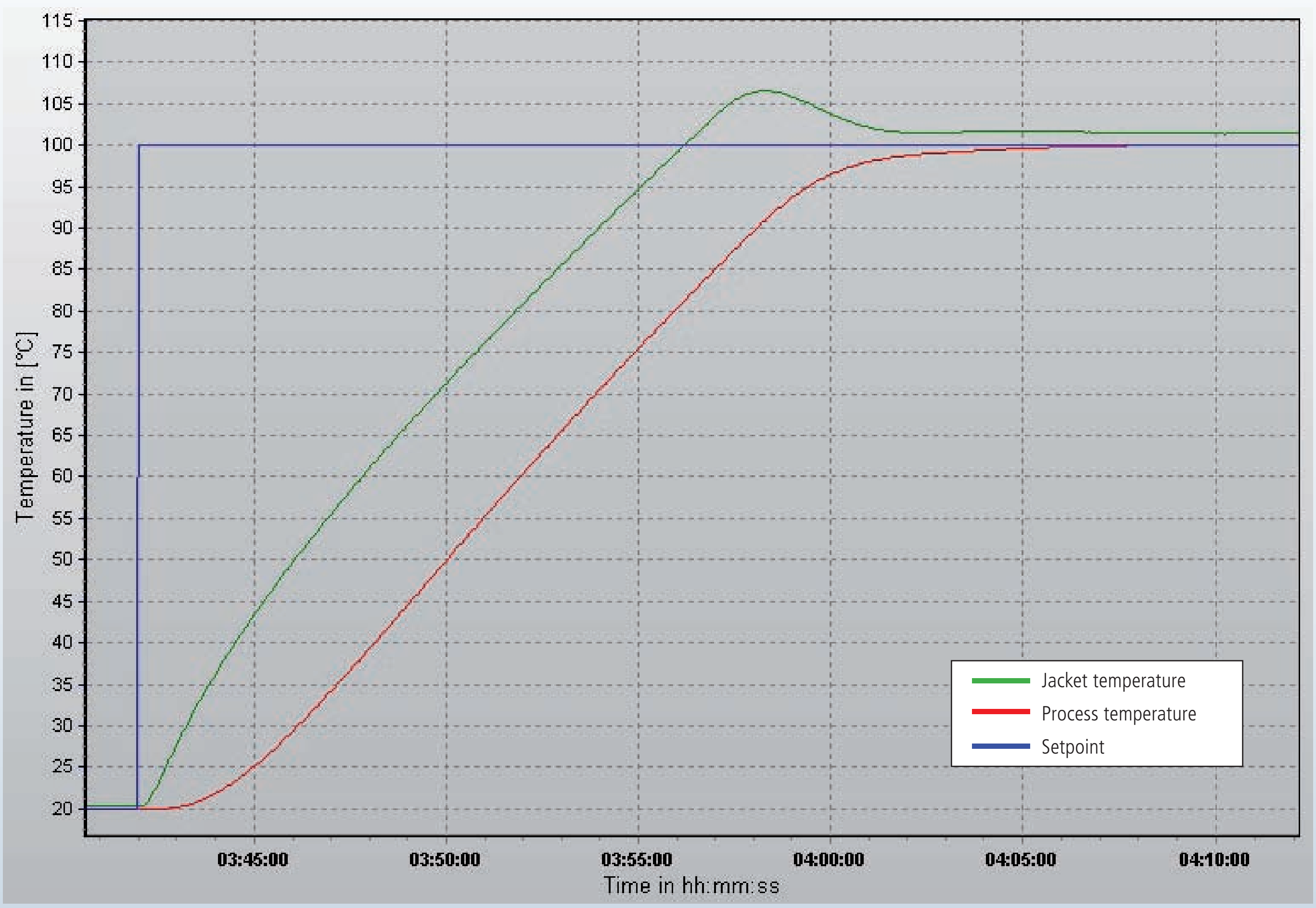
Unistat® 705w

Heating a Büchi 3-litre metal reactor from 20 °C to 100 °C

Requirement
The graphic shows the performance of a Unistat® 705w heating a Büchi 3-litre un-insulated metal pressure reactor from 20 °C to 100 °C.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 2.25 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
With a heating power of 1.5 kW the machine needs 25 minutes to heat the process through 80 K (average ramp rate of 3.2 K/min).



Version: 9/2009

Unistat® 705w

Cooling a Büchi 3-litre metal reactor from 180 °C to 20 °C

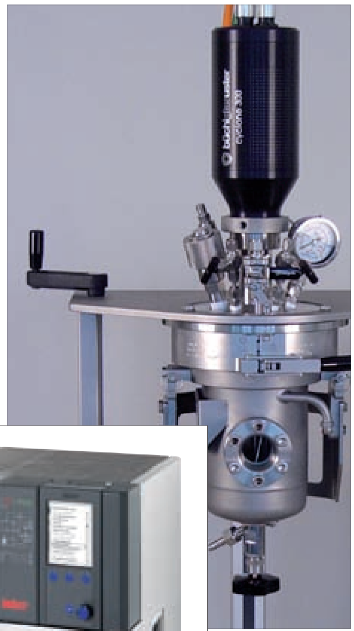
Requirement
This case study shows the performance of a Unistat® 705w cooling a Büchi 3-litre un-insulated metal pressure reactor from 180 °C to 20 °C under "process" control.

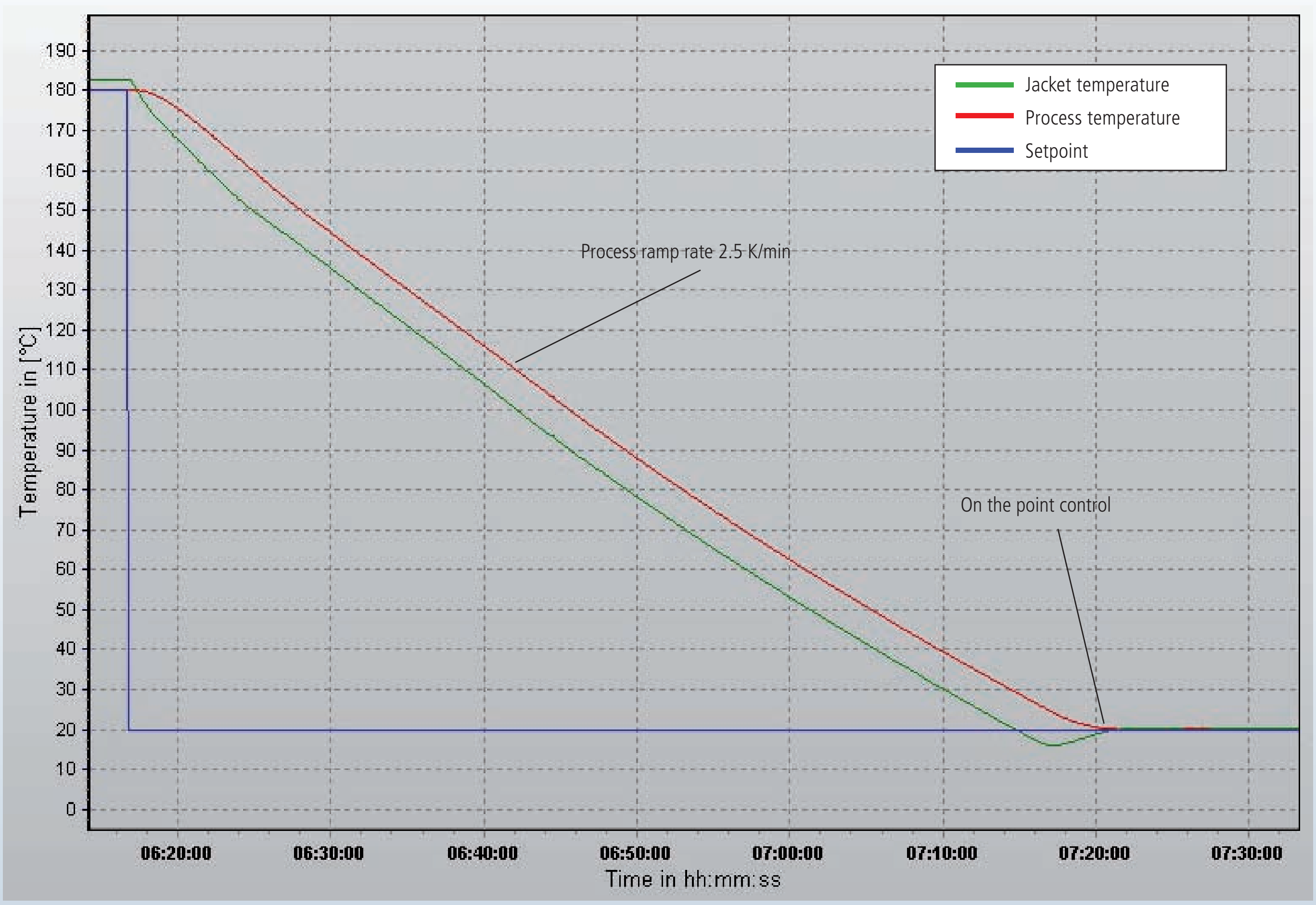
Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 2.25 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
It can be seen from the narrow ΔT between "internal" (jacket) and the process temperatures that thermal transfer in this reactor is very good. Total time to ramp the process through 160 K (180 °C to 20 °C) is approximately 65 minutes.

Setup details
Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75…250 °C
Cooling Power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating Power:	1.5 kW / 3 kW
Pump speed	3500 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	3 litre un-insulated metal pressure reactor
Reactor contents:	2.25 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process





Version: 9/2009

Setup details
Unistat® 705w & Büchi reactor (büchiglasuster)

Temperature range:	-75...250 °C
Cooling power:	0.6 kW @ 250…100 °C
	0.65 kW @ 0 °C
	0.6 kW @ -20...-40 °C
	0.3 kW @ -60 °C
Heating power:	1.5 kW / 3 kW
Pump speed:	3500 rpm
Hoses:	2x1 m; M24x1.5 (#9325)
HTF:	DW-Therm (#6479)
Reactor:	3 litre un-insulated metal pressure reactor
Reactor content	2.25 litre M90.055.03 (#6259)
Stirrer speed	200 rpm
Control	process

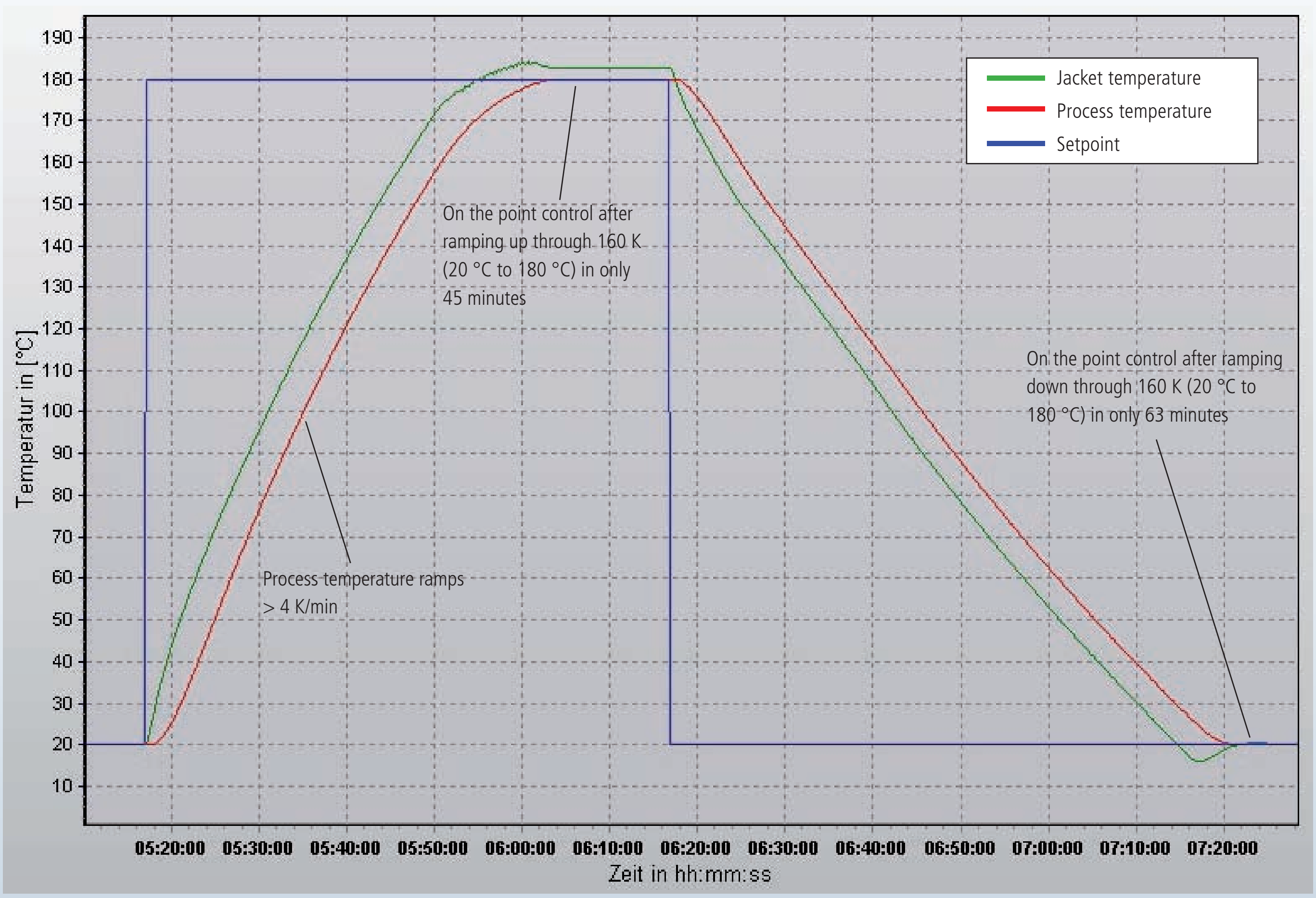
Unistat® 705w

Heating & cooling a Büchi 3-litre metal reactor

Requirement
The graphic illustrates the heating and cooling performances of Unistat® 705w working with a Büchi 3-litre un-insulated metal pressure reactor. As metal has a good conductor the heat transfer is executed in an efficient manner that the ΔT is always below 20 K.

Method
The Unistat® and reactor are connected using two 1-metre insulated metal hoses. The reactor is filled with 2.25 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The machine needs approx. 49 minutes to reach 180 °C. On the other hand it requires 64 minutes to get back to 20 °C. The heating and cooling rates for the heating and cooling processes are 4.4 K / min and 2.7 K / min.



Version: 9/2009

Unistat® 825w

Controlling a 300 W (258 kcal/hr) simulated exothermic reaction in a Büchi 10-litre jacketed glass reactor

Requirement

An exothermic reaction is simulated inside a Büchi 10-litre glass reactor with an electric heater. A sudden heat input of 300 W (258 cal/hr) is introduced to demonstrate the response of the Unistat® 825w.

Method

The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

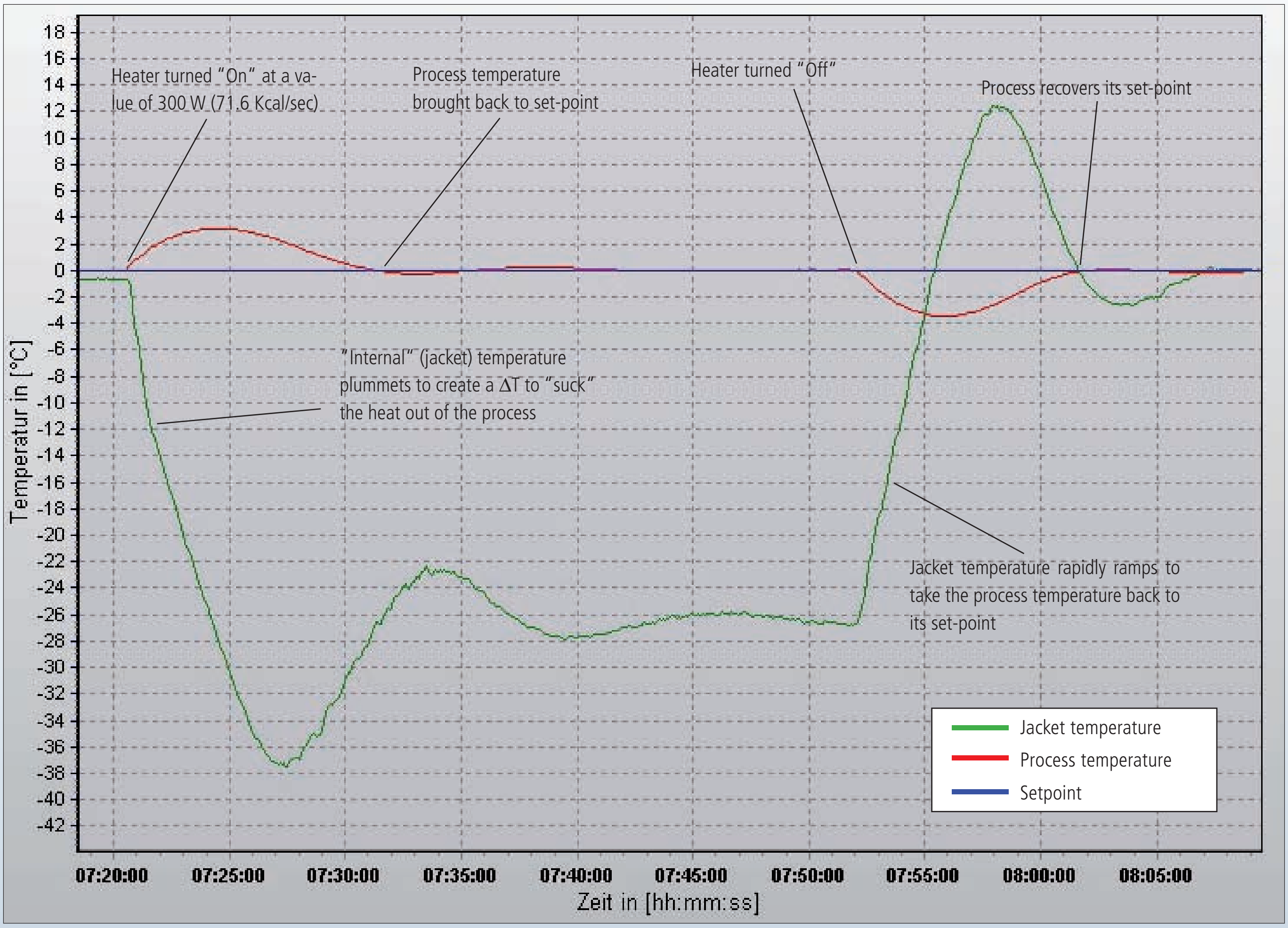
Results

The process temperature increases by 3.2 K and is controlled back to 0 °C within 11 minutes.
The heater is then turned "Off". The process temperature falls by 3.5 K but is recovered to its set-point within 10 minutes.

Setup details

Unistat® 825w & Büchi «miniPilot» 10 reactor (büchiglasuster)

Temperature range:	-85…250 °C
Cooling power:	2.4 kW @ 0…-40 °C 1.5 kW @ -60 °C
Heating power:	3.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process



Setup details
Unistat® 825w & Büchi «miniPilot» 10 reactor (büchiglasuster)

Temperature range:	-85…250 °C
Cooling power:	2.4 kW @ 0…-40 °C 1.5 kW @ -60 °C
Heating power:	3.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process

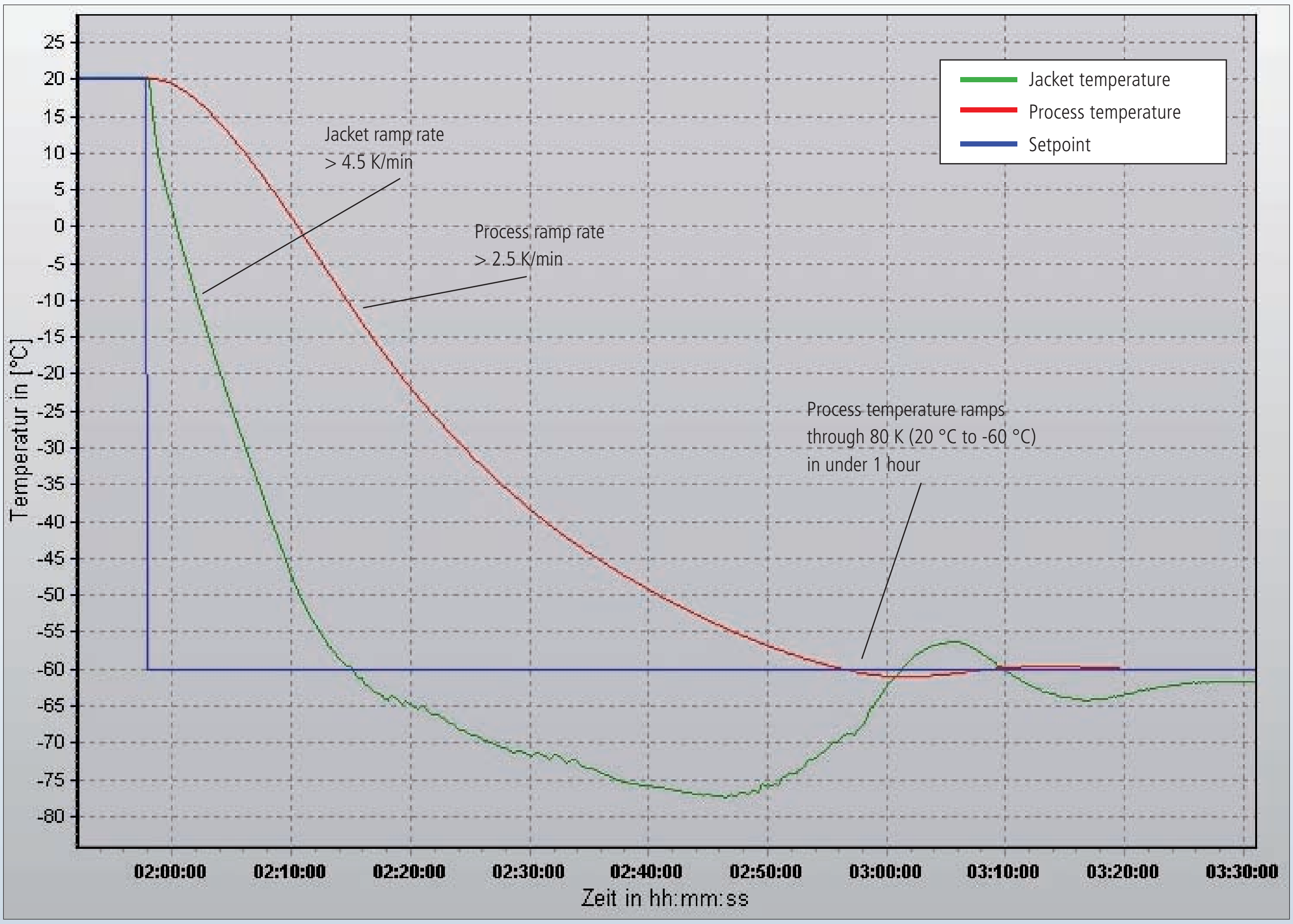
Unistat® 825w

Cooling a Büchi 10-litre reactor from 20 °C to -60 °C

Requirement
The graphic shows the cooling performance of a Unistat® 825w when cooling a Büchi 10-litre reactor under process control from 20 °C to -60 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The internal temperature cools to approximately -78 °C to remove the heat from the reactor to pull the process temperature to its set-point.



Version: 9/2009

Unistat® 825w

Cooling a Büchi 10-litre jacketed glass reactor from 20 °C to T_{min}

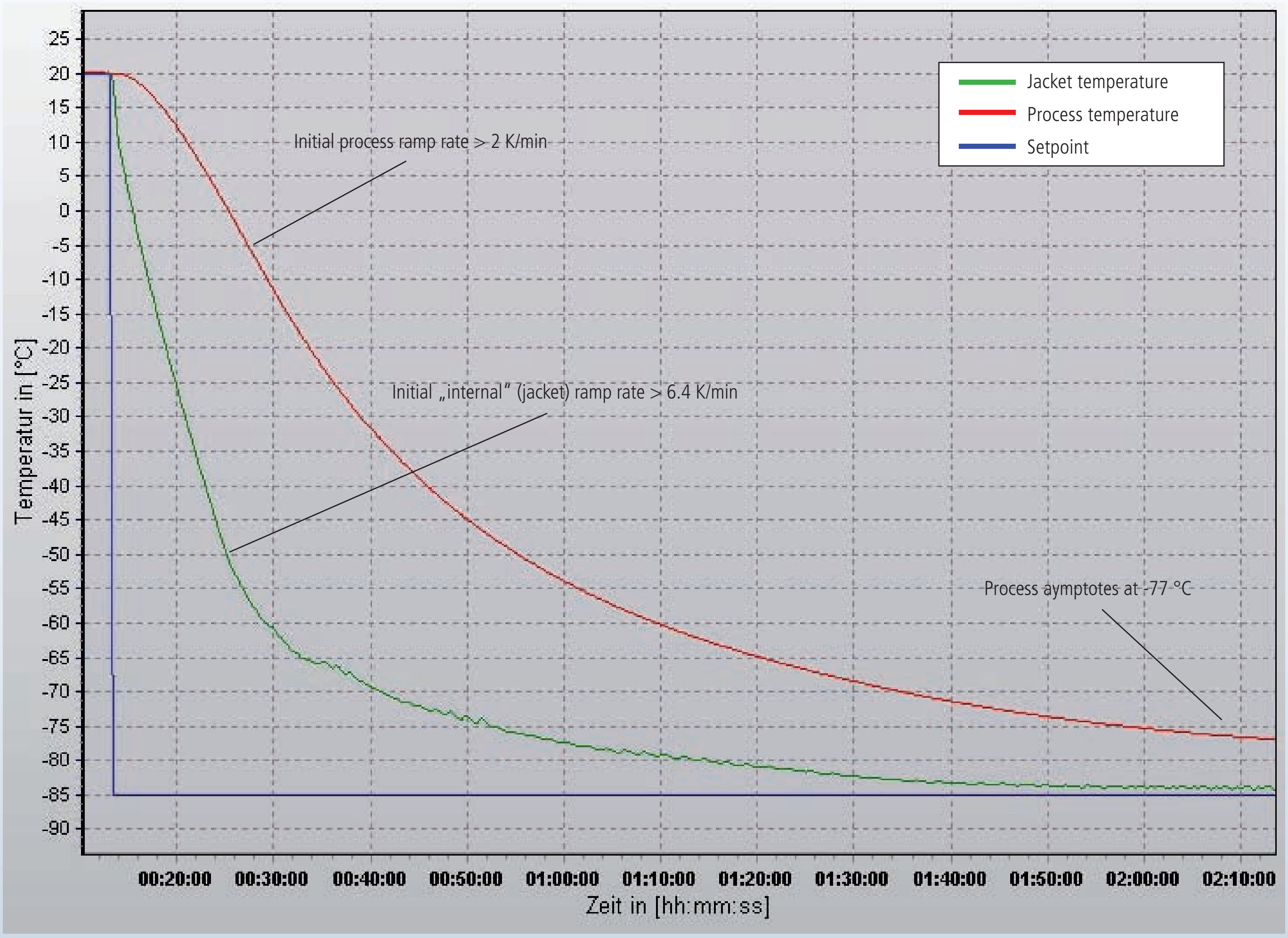
Requirement
The graphic shows the performance of a Unistat® 825w cooling a Büchi 10-litre reactor from 20 °C to -85 °C under "process" control.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The internal temperature reaches -80 °C within 1:13 hr. Over the remainder of the 2 hour case study the internal (jacket) temperature reaches -84 °C with a corresponding process temperature of -77 °C.

Setup details
Unistat® 825w & Büchi «miniPilot» 10 reactor (büchiglasuster)

Temperature range:	-85…250 °C
Cooling power:	2.4 kW @ 0…-40 °C 1.5 kW @ -60 °C
Heating power:	3.0 kW
Pump speed:	3.500 rpm
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	internal



Setup details
Unistat® 825w & Büchi «miniPilot» 10 reactor (büchiglasuster)

Temperature range:	-85…250 °C
Cooling power:	2.4 kW @ 0…-40 °C 1.5 kW @ -60 °C
Heating power:	3.0 kW
Pump speed:	3500 rpm
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process

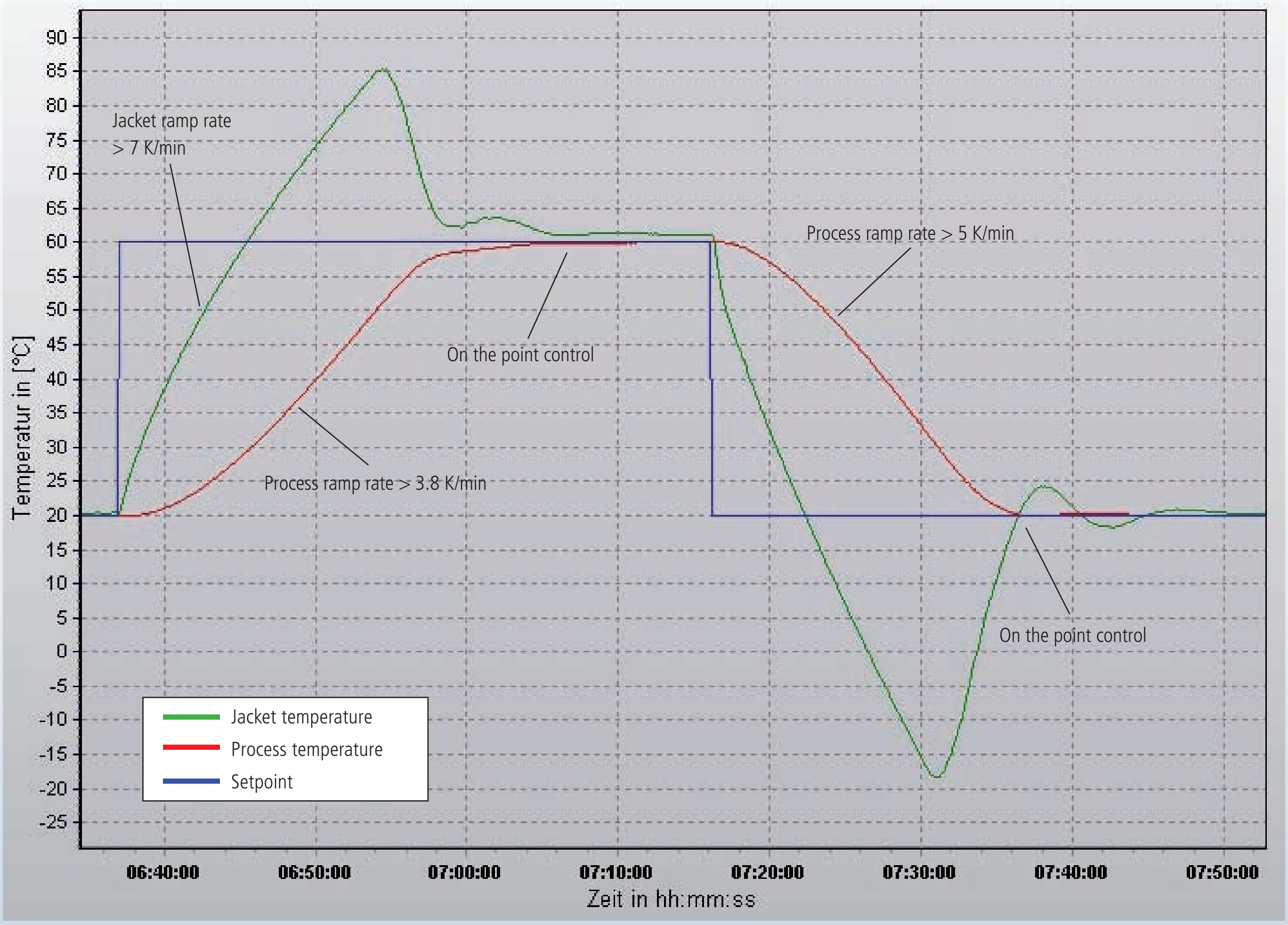
Unistat® 825w

Heating and cooling a Büchi 10-litre reactor

Requirement
The graphic illustrates the performance temperature of a Unistat® 825w heating and cooling a Büchi 10-litre reactor between 20 °C and 60 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process temperature heats at a ramp rate of 3.8 K / min taking 30 minutes to reach the set-point. The cooling ramp rate is at a rate of 5.7 K/min and takes 27 minutes to cool through 40 K (60 °C to 20 °C).



Version: 9/2009

Unistat® 825w

Heating and cooling a Büchi 10-litre jacketed reactor

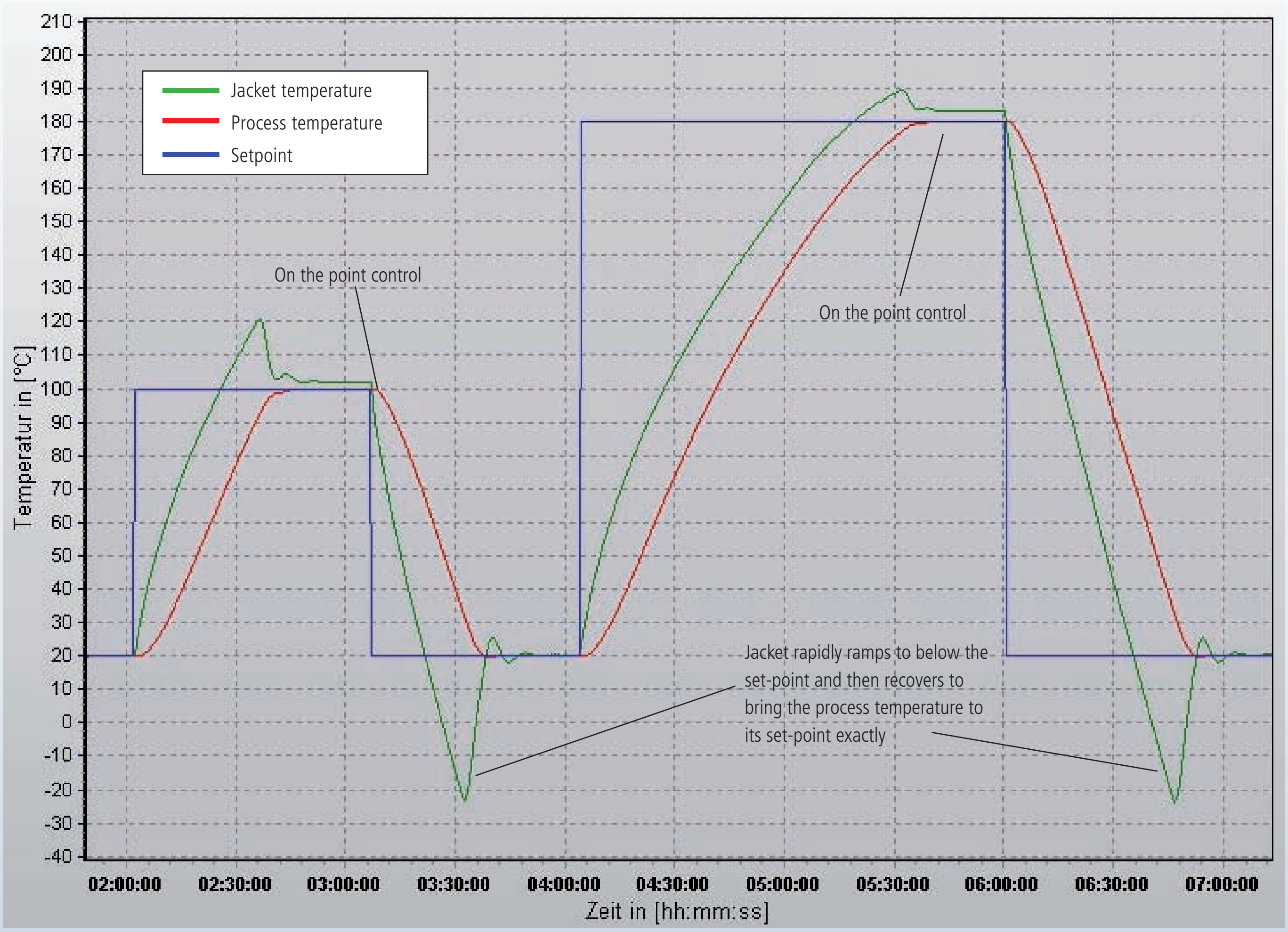
Requirement
This case study intended to investigate the performance of a Unistat® 825w heating and cooling a Büchi 10-litre reactor between 20 °C to 100 °C and then from 20 °C to 180 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
In the first segment (20 °C to 100 °C) the heating ramp rate of 2.94 K / min heats the process temperature to 100 °C in 47 minutes.
In the second segment (20 °C to 180 °C) the average heating ramp rate of 1.9 K / min brings the process temperature to the set-point within 1:47 hour.

Setup details
Unistat® 825w & Büchi «miniPilot» 10 reactor (büchiglasuster)

Temperature range:	-85…250 °C
Cooling power:	2.4 kW @ 0…-40 °C 1.5 kW @ -60 °C
Heating power:	3.0 kW
Pump speed:	3500 rpm
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process



Setup details
Unistat® 830 & DDPS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
	3.6 @ 0 °C
	3.5 @ -20...-40 °C
	2.2 @ -60 °C
	0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated jacketed glass reactor
Reactor contents:	18.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process

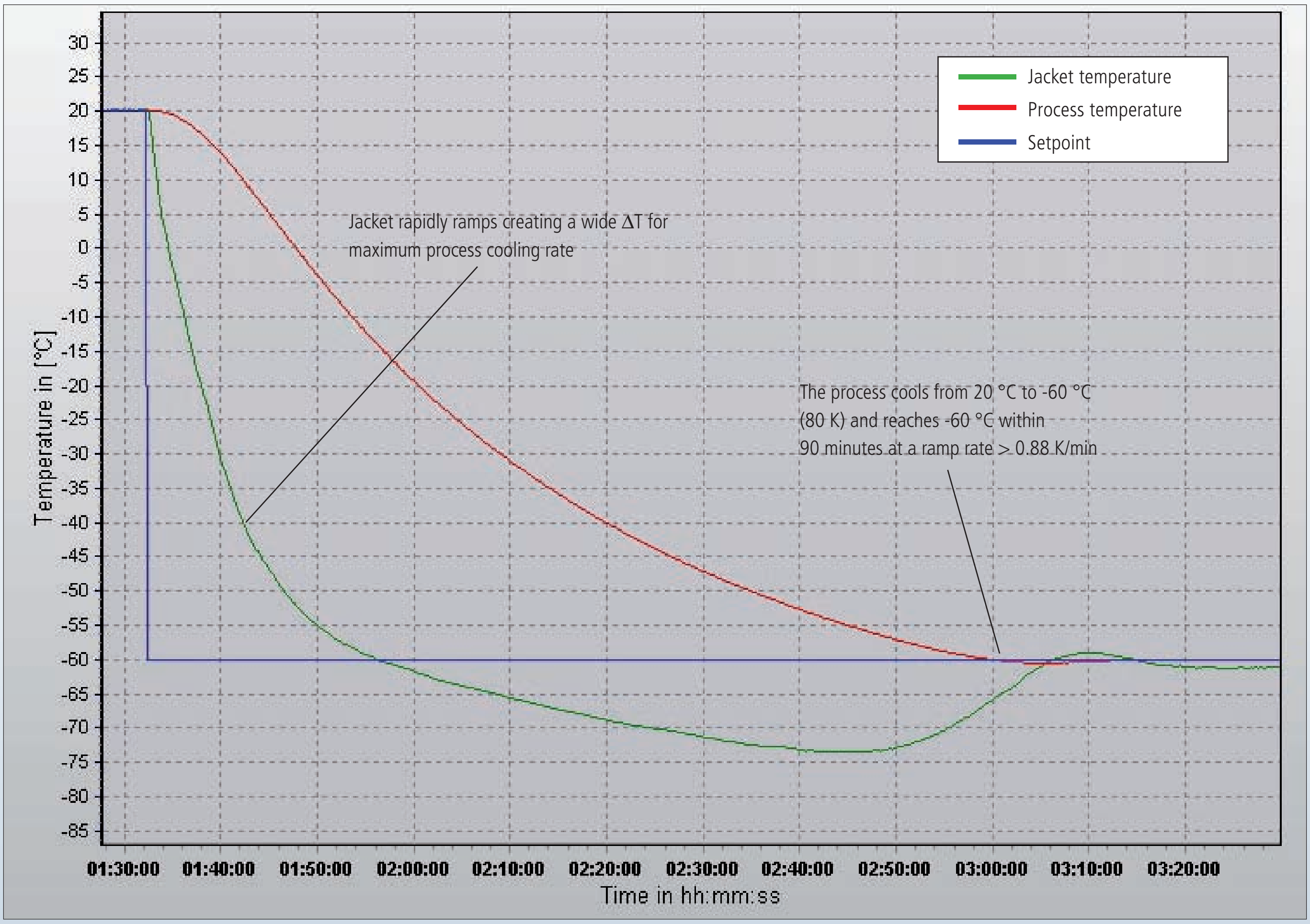
Unistat® 830

Cooling a DDPS 25-litre glass reactor to -60 °C

Requirement
The test is conducted to investigate the cooling performance of a Unistat® 830 cooling the process temperature to -60 °C in a DDPS 25-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
With a cooling power of 2.2 kW at -60 °C the Unistat® provides a cooling rate of approx. 0.88 K / min to the process. In 90 minutes the process temperature reaches the required setpoint.



Version: 9/2009

Unistat® 830

300 W (258 kcal/hr) & 600 W (516 kcal/hr) exothermic reactions in a DDPS 25-litre glass reactor

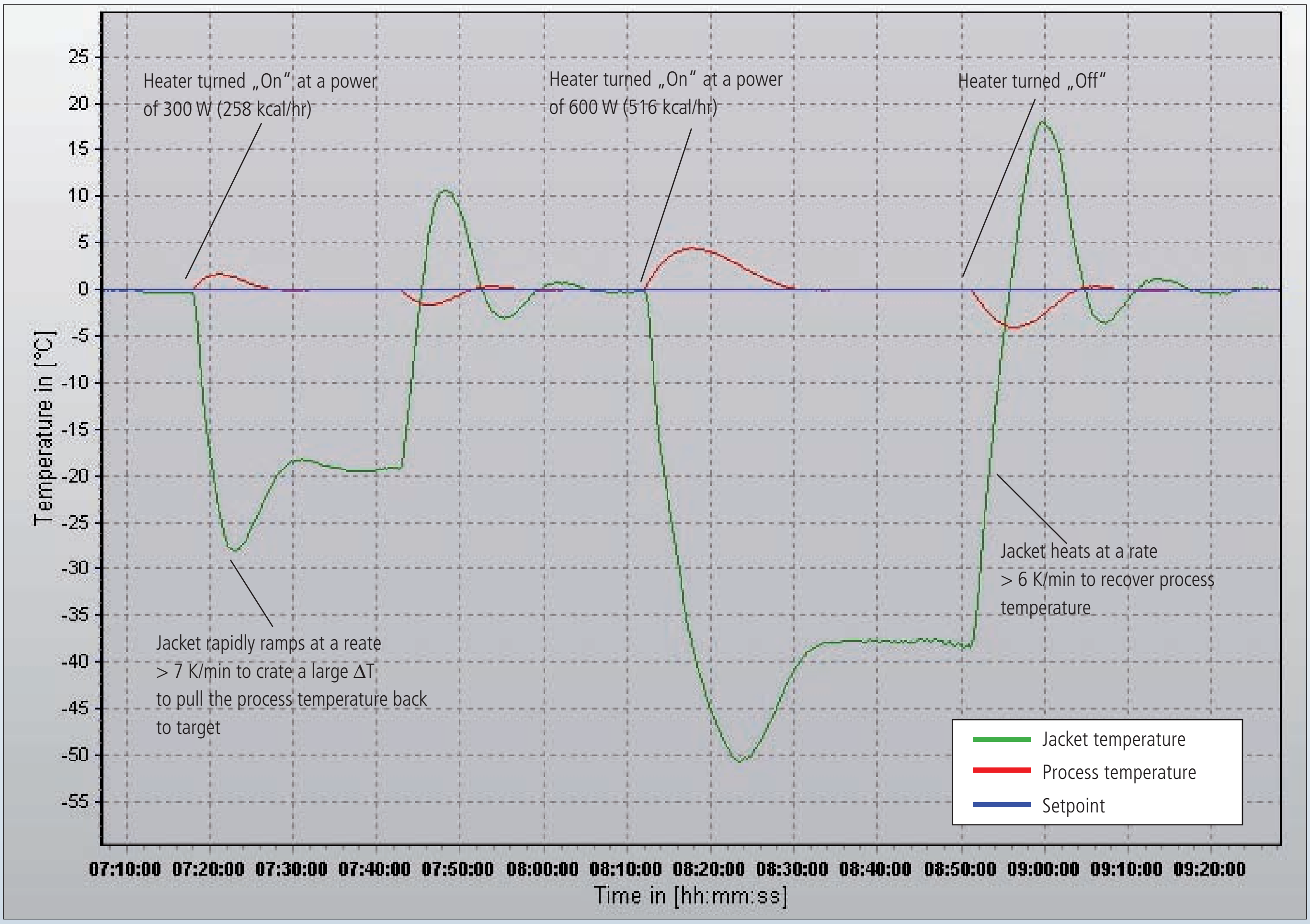
Requirement
A Unistat® 830 is used to compensate the sudden temperature rise due to an exothermic reaction of 300 W and 600 W. The simulated heat input is introduced on a DDPS 25-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
With the 300 W heat input the temperature rises by approx. 1.6 K and the Unistat® needs approx. 9 minutes to bring back the process temperature down to the set-point. Meanwhile the 600 W heat addition results in approx. 4.3 K of temperature rises and within 18 minutes it is back under control at the set-point.

Setup details
Unistat® 830 & DDPS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C 3.6 @ 0 °C 3.5 @ -20...-40 °C 2.2 @ -60 °C 0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated jacketed glass reactor
Reactor contents:	18.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process



Setup details
Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C 3.6 @ 0 °C 3.5 @ -20...-40 °C 2.2 @ -60 °C 0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	20 litre un-insulated jacketed metal pressure reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process

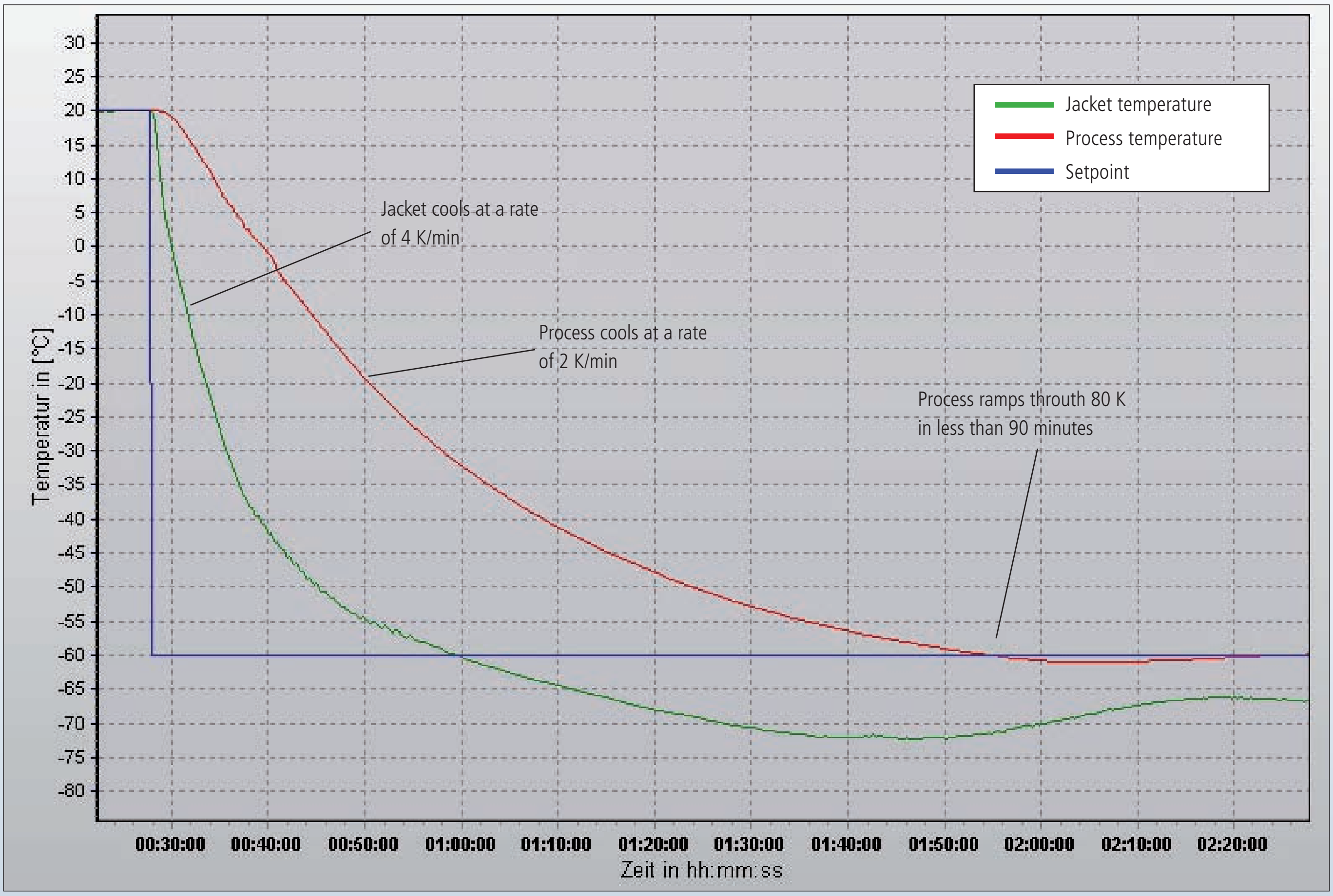
Unistat® 830

Cooling a Büchi 20-litre metal pressure reactor to -60 °C

Requirement
This case study is to look at the performance of a Unistat® 830 as it cools a Büchi 20-litre jacketed metal reactor to -60 °C from 20 °C (80 K).

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The jacket cools with an initial ramp rate of 4 K / min and the process follows at a ramp rate of 2 K / min.
The process cools smoothly through 80 K to its set-point of -60 °C in under 90 minutes.



Unistat® 830

Cooling a HWS 5-litre jacketed reactor to T_{min}

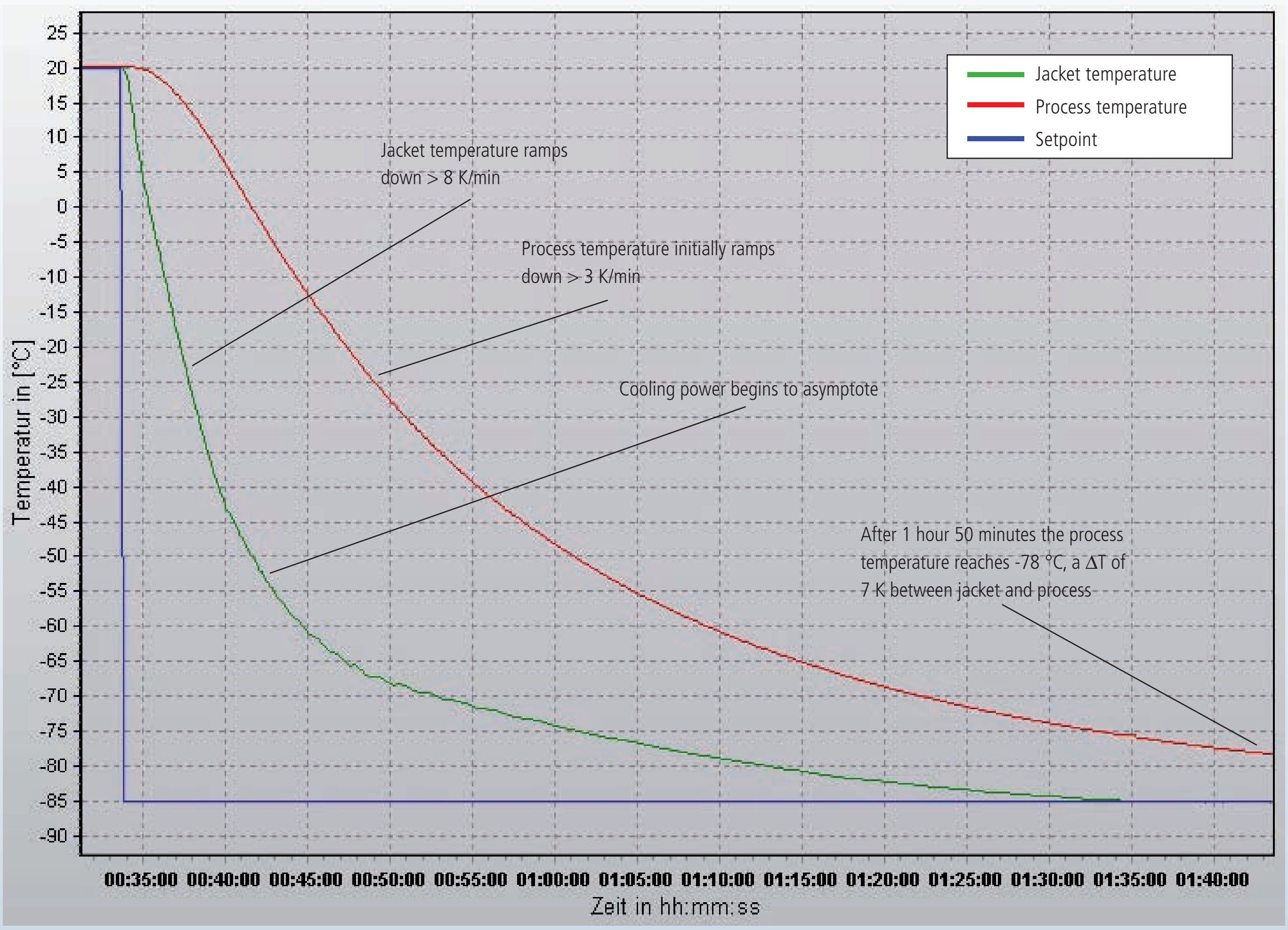
Requirement
The graphic shows the performance of a Unistat® 830 working with a HWS 5-litre glass reactor. This test is conducted with internal control mode in order to measure the lowest possible temperature that can be reached by the machine.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 3.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The machine reaches a minimum temperature of -85 °C in 60 minutes pulling the process temperature down to -75 °C.

Setup details
Unistat® 830 & HWS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
	3.6 @ 0 °C
	3.5 @ -20...-40 °C
	2.2 @ -60 °C
	0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Unistat® 830

Controlling a simulated exothermic reaction of 200 W (172 kcal/hr) in a HWS 5-litre jacketed glass reactor

Setup details
Unistat® 830 & HWS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
	3.6 @ 0 °C
	3.5 @ -20...-40 °C
	2.2 @ -60 °C
	0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process

Requirement

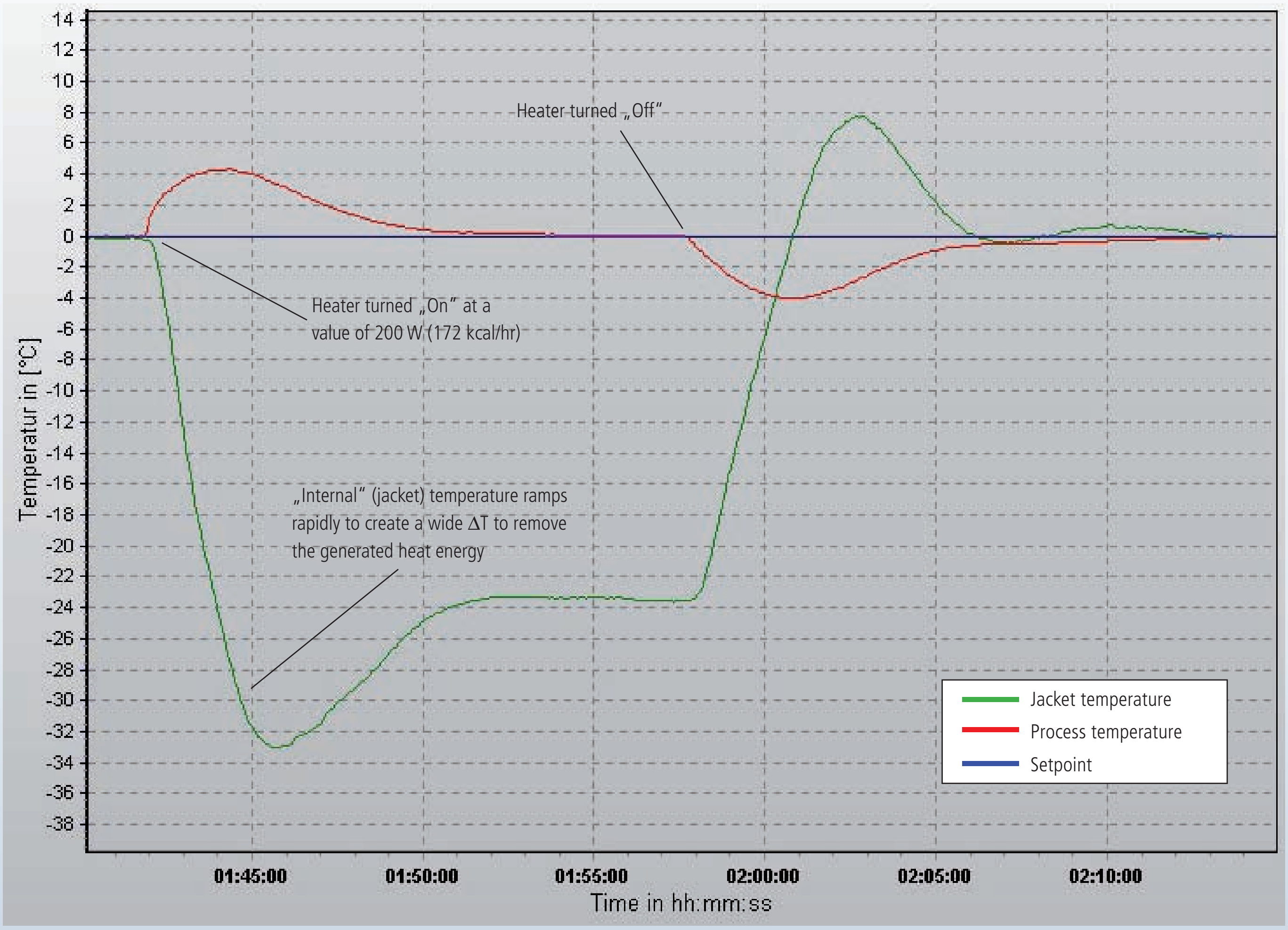
This case study shows the ability of the Unistat® 830 to control exothermic reactions in a HWS 5-litre glass reactor.

Method

The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 3.75 litre of "M90.055.03", a Huber supplied silicon based HTF. The exothermic reactions are simulated using a controlled electric immersion heater.

Results

An exothermic reaction of 200 W (172 kcal / hr) is simulated at 0 °C. The process curve shows how fast the Unistat® 830 compensates a sudden rise in process temperature.
When the process temperature increases due to the heat from the simulated exothermic reaction the "internal" (jacket) temperature reacts immediately. The "exothermic" energy results in an increase in process temperature of 4.2 K before the reaction is brought under control and the process temperature is cooled back to the set-point of 0 °C in 13 minutes.



Version: 9/2009

Unistat® 830

Cooling a HWS 5-litre reactor from 20 °C to -60 °C

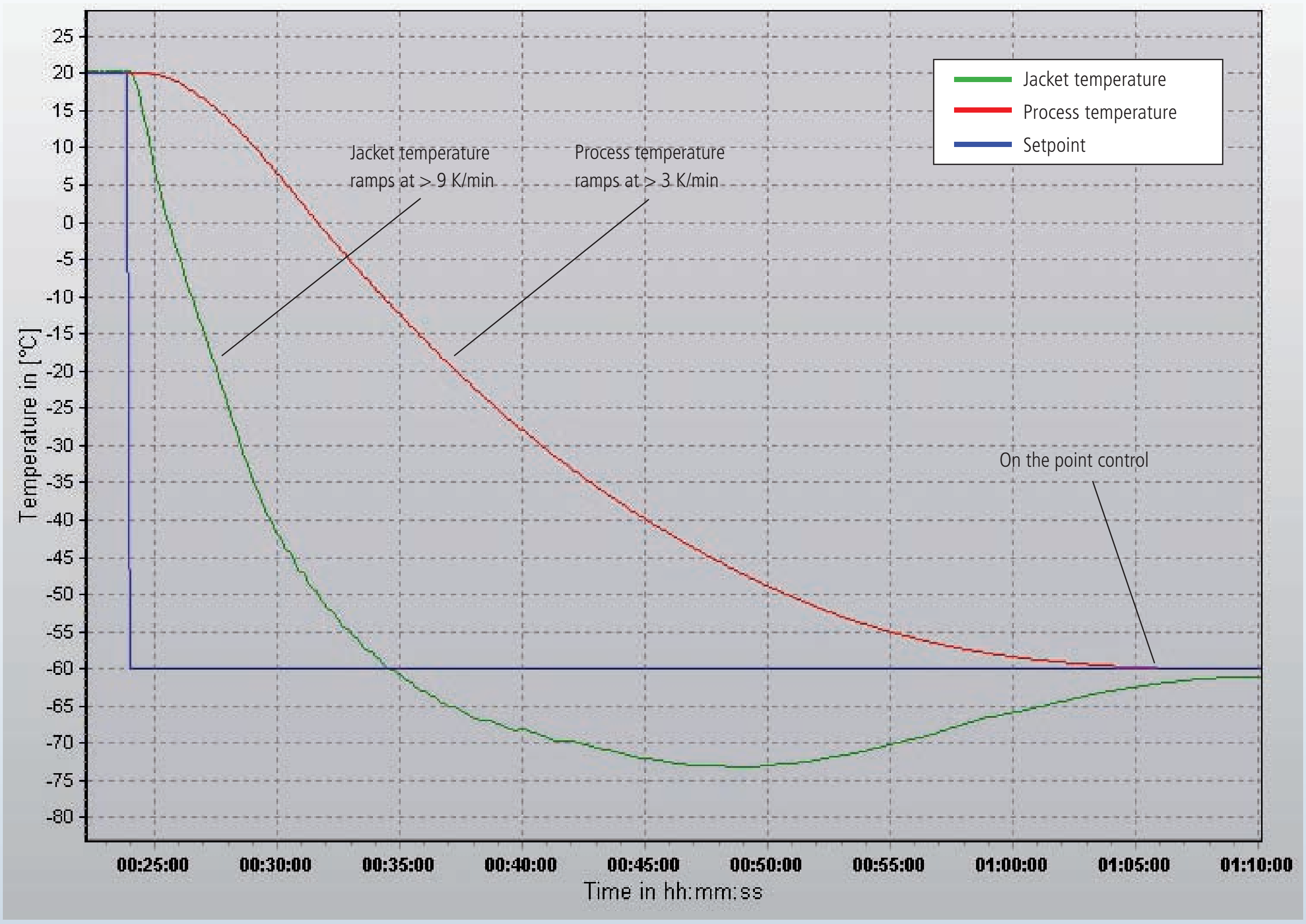
Requirement
The diagram illustrates the cooling curve of a Unistat® 830 cooling a HWS 5-litre reactor to -60 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 3.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The result shows that the process temperature ramps through 80 K (20 °C to -60 °C) and reaches the required set-point in 43 minutes and remains stable at the new set-point.

Setup details
Unistat® 830 & HWS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
	3.6 @ 0 °C
	3.5 @ -20...-40 °C
	2.2 @ -60 °C
	0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Technical details and dimensions are subject to change. No liability is accepted for errors or ommisions.

Setup details
Unistat® 830 & HWS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C 3.6 @ 0 °C 3.5 @ -20...-40 °C 2.2 @ -60 °C 0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process

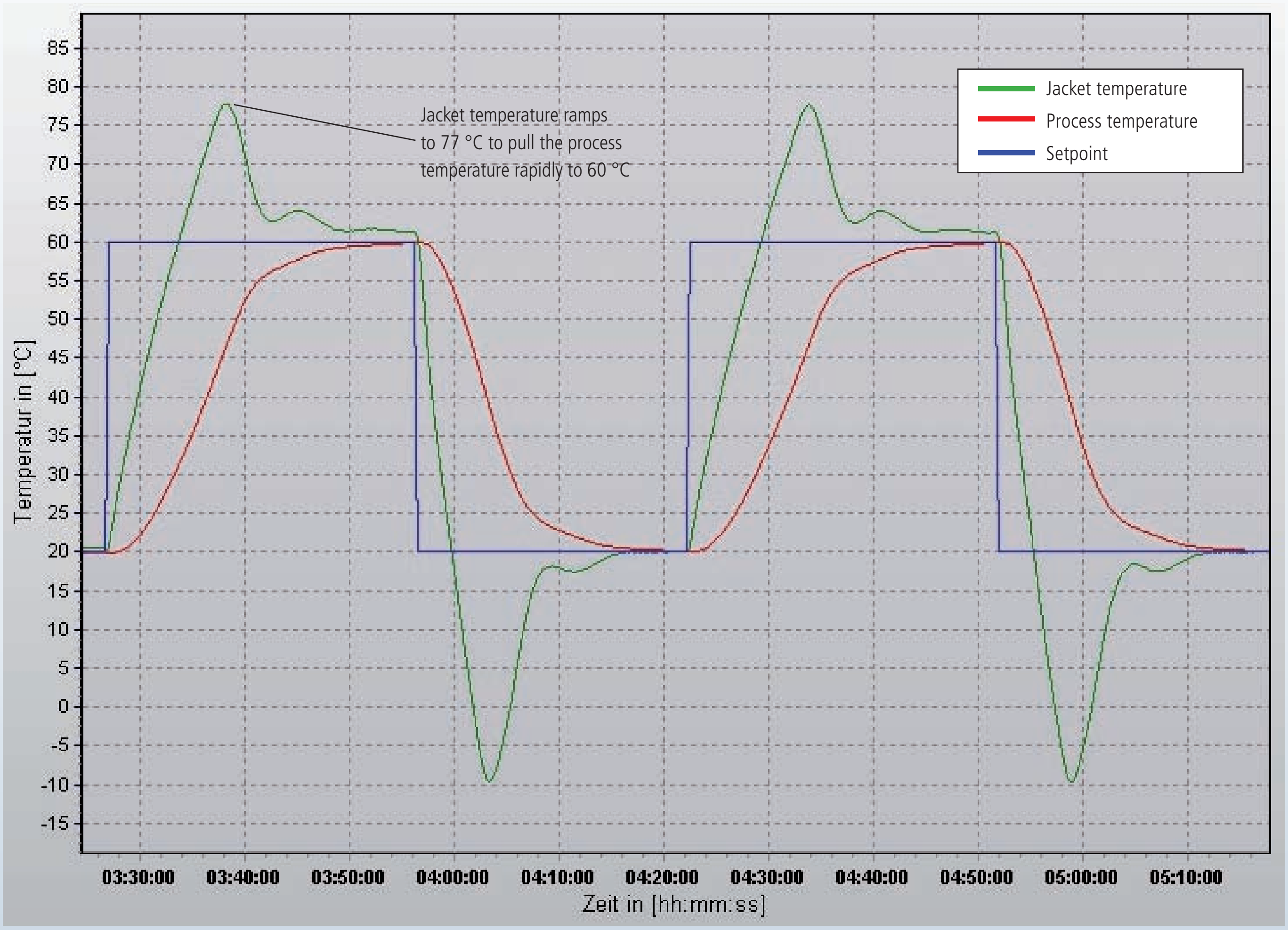
Unistat® 830

Consistent and reproducible results with a 5-litre reactor

Requirement
The graphic illustrates two identical segments which are designed to test the capability of the machine to produce consistent result.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 3.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The heating and cooling curves are identical demonstrating the consistency of control. For heating processes the machine needs 28 minutes to reach 60 °C from 20 °C. The cooling process takes 25 minutes to cool back to 20 °C.



Version: 9/2009

Unistat® 830

Heating and cooling a HWS 5-litre reactor

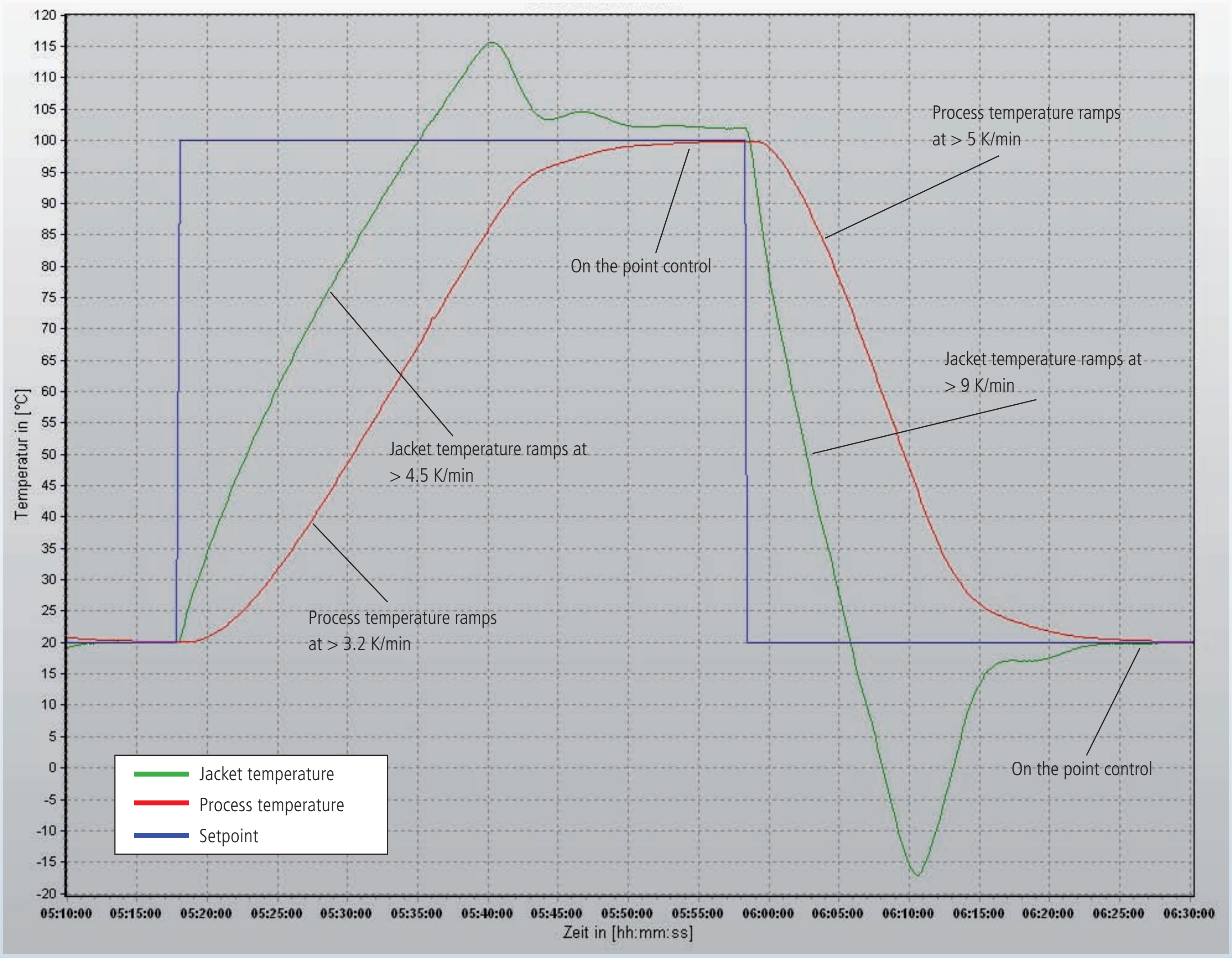
Requirement
The graphic shows the heating and cooling performance of a Unistat® 830 alternating between temperature set-points of 20 °C and 100 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 3.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
For the heating process the internal temperature jumps to approximately 115 °C in 23 minutes. This is heating ramp rate average of 4.13 K / min to the process. As a result the process temperature reaches 100 °C in 40 minutes.
For the cooling curve, the internal temperature cools to -17 °C in 12 minutes. This represents an average cooling ramp rate of 3.1 K / min. The set-point of 20 °C is reached within 28 minutes.

Setup details
Unistat® 830 & HWS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C 3.6 @ 0 °C 3.5 @ -20...-40 °C 2.2 @ -60 °C 0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	5 litre jacketed glass reactor
Reactor contents:	3.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	200 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
	3.6 @ 0 °C
	3.5 @ -20...-40 °C
	2.2 @ -60 °C
	0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process

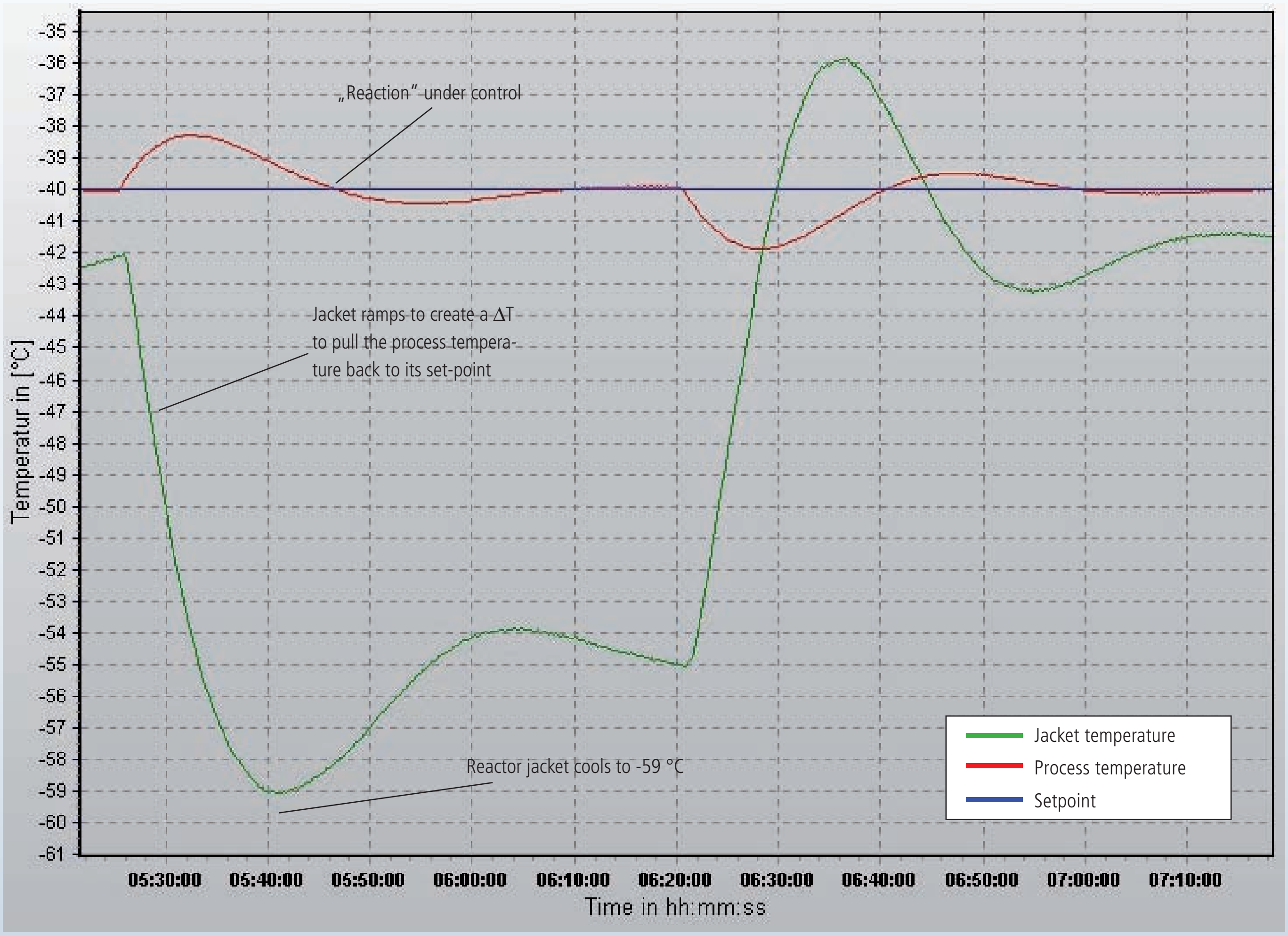
Unistat® 830

Controlling a simulated 150 W (129 kcal / hr) exothermic reaction in a Büchi 20-litre jacketed glass reactor @ -40 °C

Requirement
This case study looks at the performance of a Unistat® 830 as it controls a 150 W (129 kcal / hr) in a Büchi 20-litre jacketed glass reactor. The reaction is carried out at -40 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF. The exothermic reactions are simulated using a controlled electric immersion heater.

Results
The "exotherm" is started by turning on the heater and causes a rise in process temperature peaking at approximately -38.2 °C. The jacket temperature rapidly cools through 17 K to -59 °C and quickly returns the process to and controls it at the set-point of -40 °C. Once the heater is turned "Off", the process cools but again, the swift response of the jacket minimises the under-shoot and the process is returned to its set-point.



Version: 9/2009

Unistat® 830

Cooling a Büchi 20-litre jacketed glass reactor to T_{min}

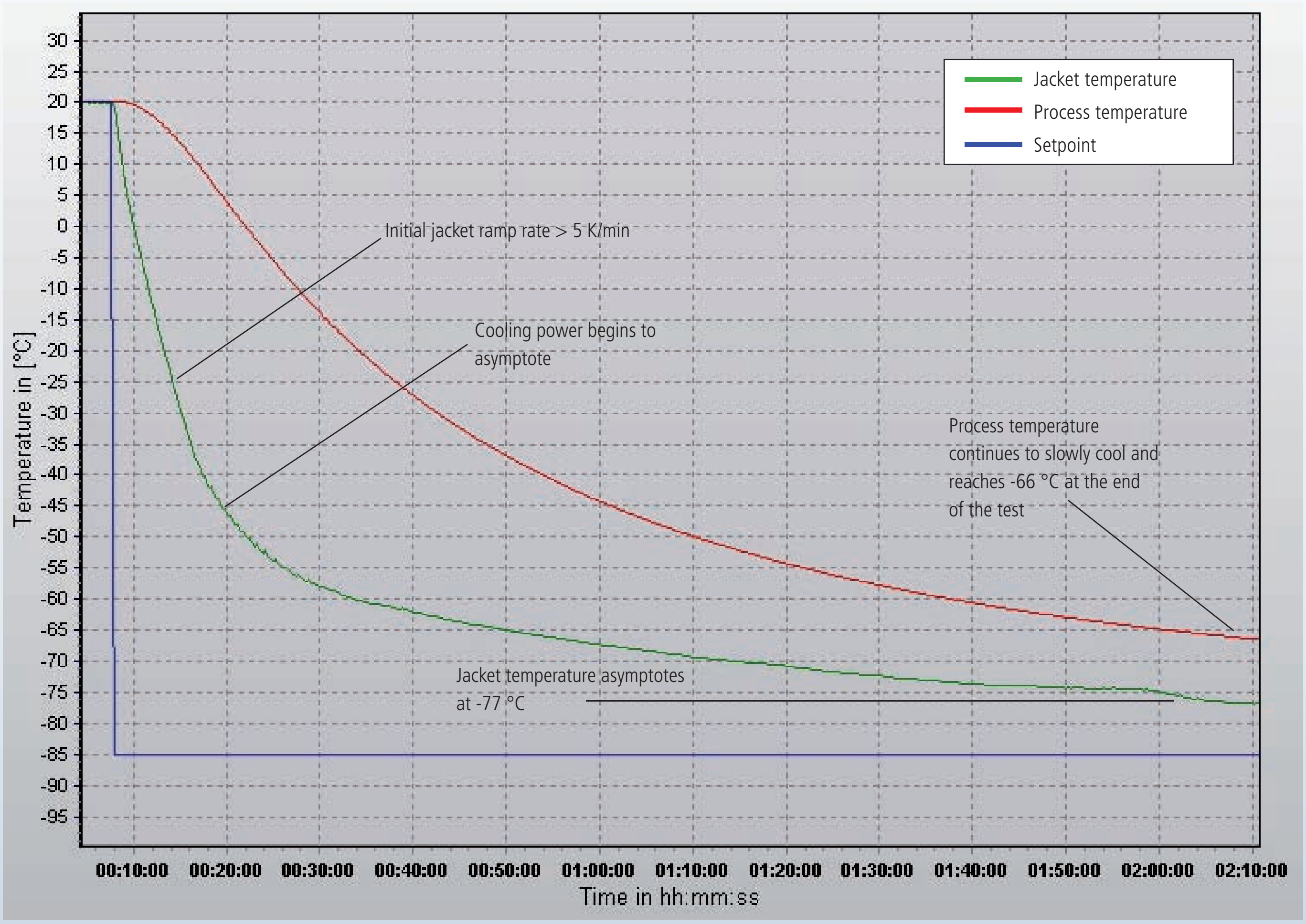
Requirement
This test is designed to determine the minimum achievable temperature that the Unistat® 830 can cool a Büchi 20 litre reactor within 2 hours.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The „internal" (jacket) temperature cools to -57 °C in the first 20 minutes before the cooling power begins to asymptote. The final temperatures of jacket and process are -77 °C and -66 °C respectively.

Setup details
Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C 3.6 @ 0 °C 3.5 @ -20...-40 °C 2.2 @ -60 °C 0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
	3.6 @ 0 °C
	3.5 @ -20...-40 °C
	2.2 @ -60 °C
	0.7 @ -80 °C
Pump speed:	3500 rpm
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#9616)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process

Unistat® 830

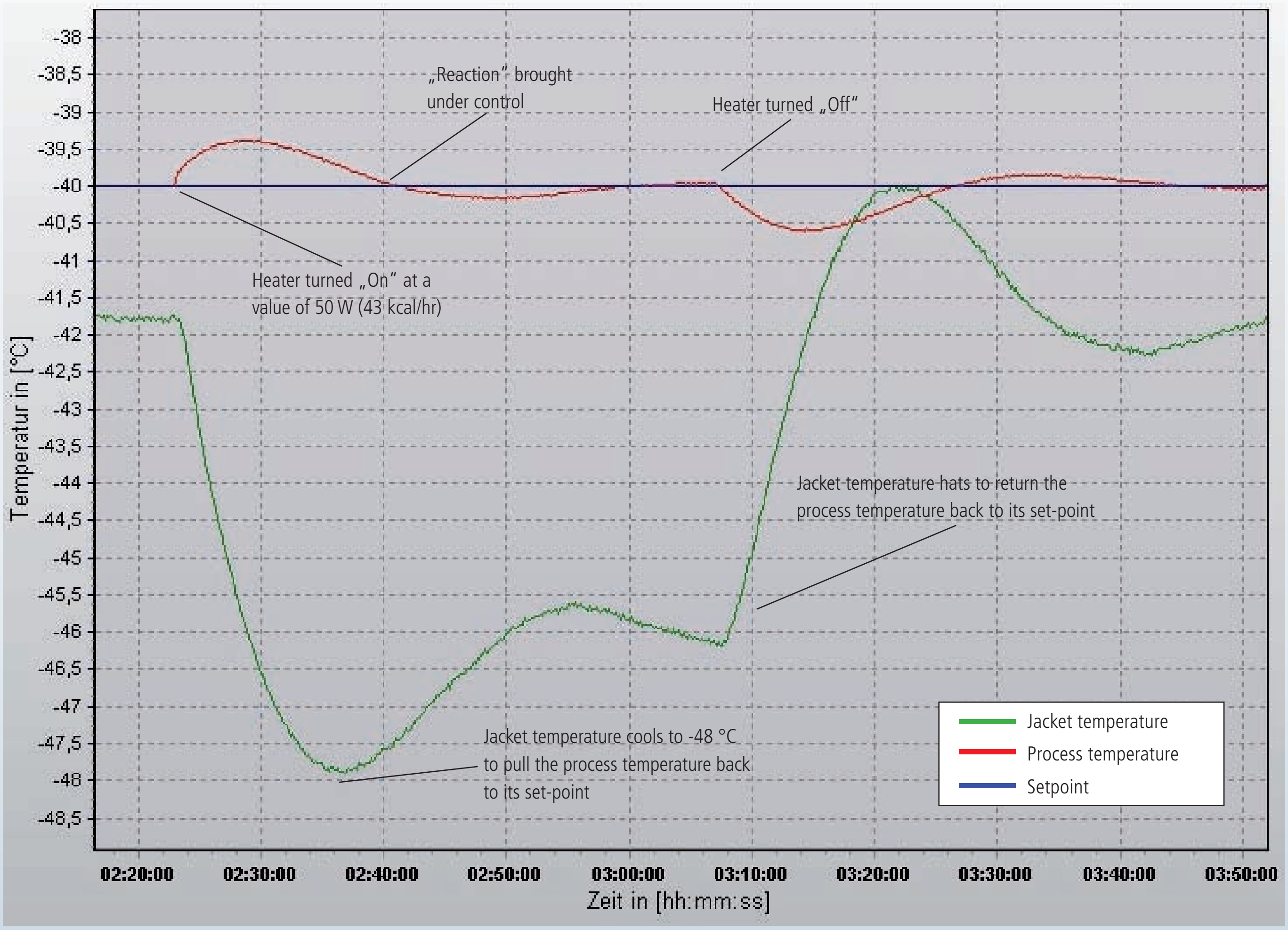
Controlling simulated exothermic reactions in a Büchi 20-litre glass reactor @ -40 °C

Requirement
This case study is to see the response of a Unistat® 830 controlling simulated exothermic reactions in a Büchi 20-litre reactor at -40 °C:
1.) 50 Watt (43 kcal/hr)
2.) 100 Watt (86 kcal/hr)
3.) 150 Watt (129 kcal/hr)

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF. The exothermic reactions are simulated using a controlled electric immersion heater.

Results
In each case the jacket temperature responds immediately to return the process temperature to its set-point and maintain exactly the set-point during the "exotherm".

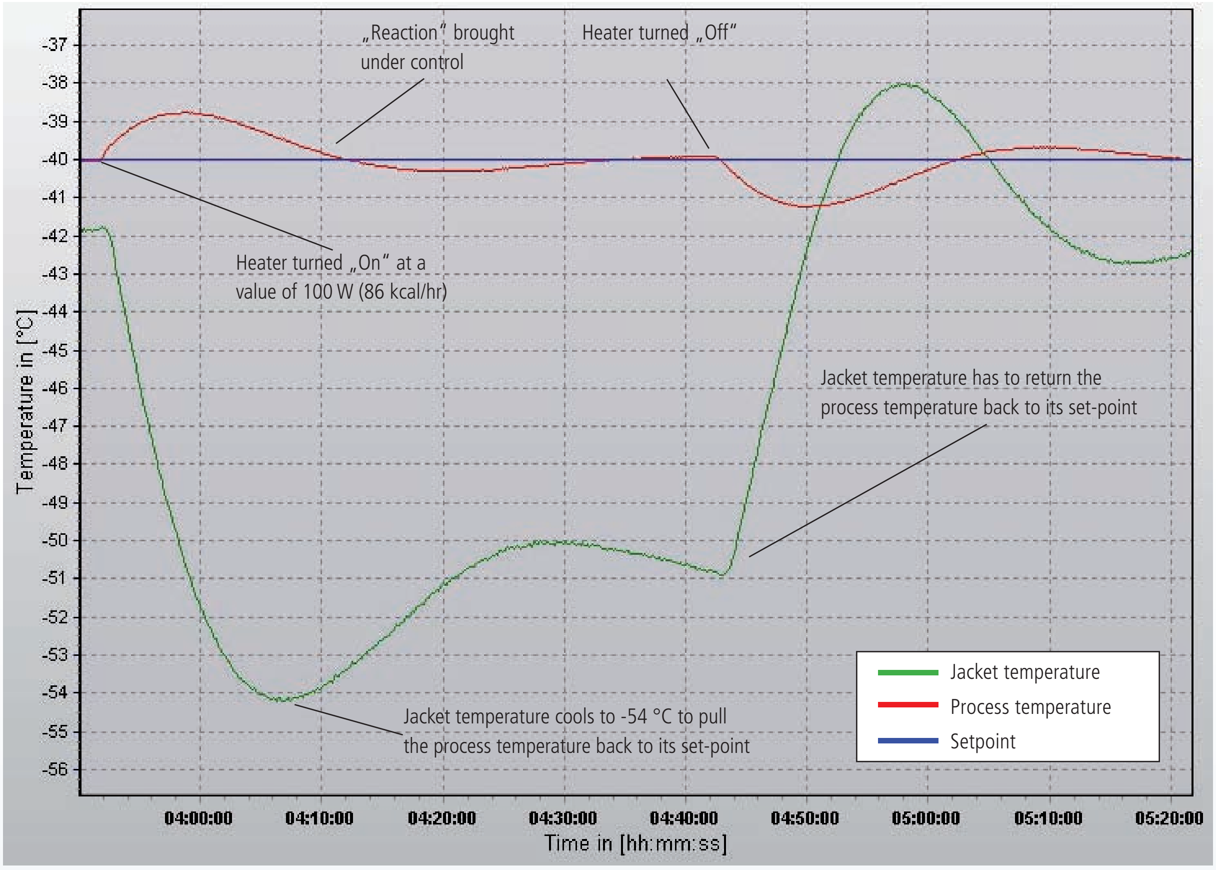
1.) 50 W (43 kcal/hr)



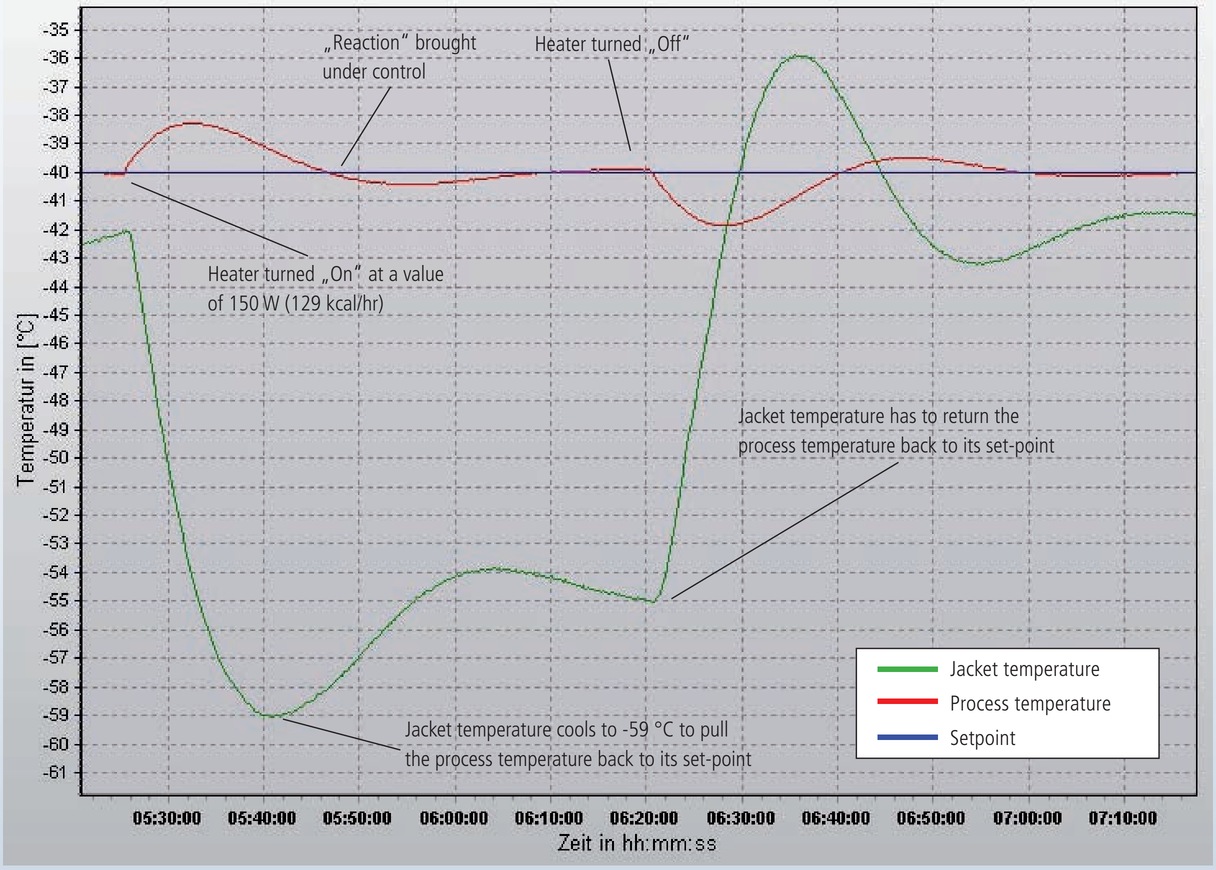
Technical details and dimensions are subject to change. No liability is accepted for errors or ommisions.

Version: 9/2009

2.) 100 W (86 kcal/hr)



3. 150 W (129 kcal / hr)



Setup details
Unistat® 830 & Radleys reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
	3.6 @ 0 °C
	3.5 @ -20...-40 °C
	2.2 @ -60 °C
	0.7 @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	80 rpm
Control:	internal

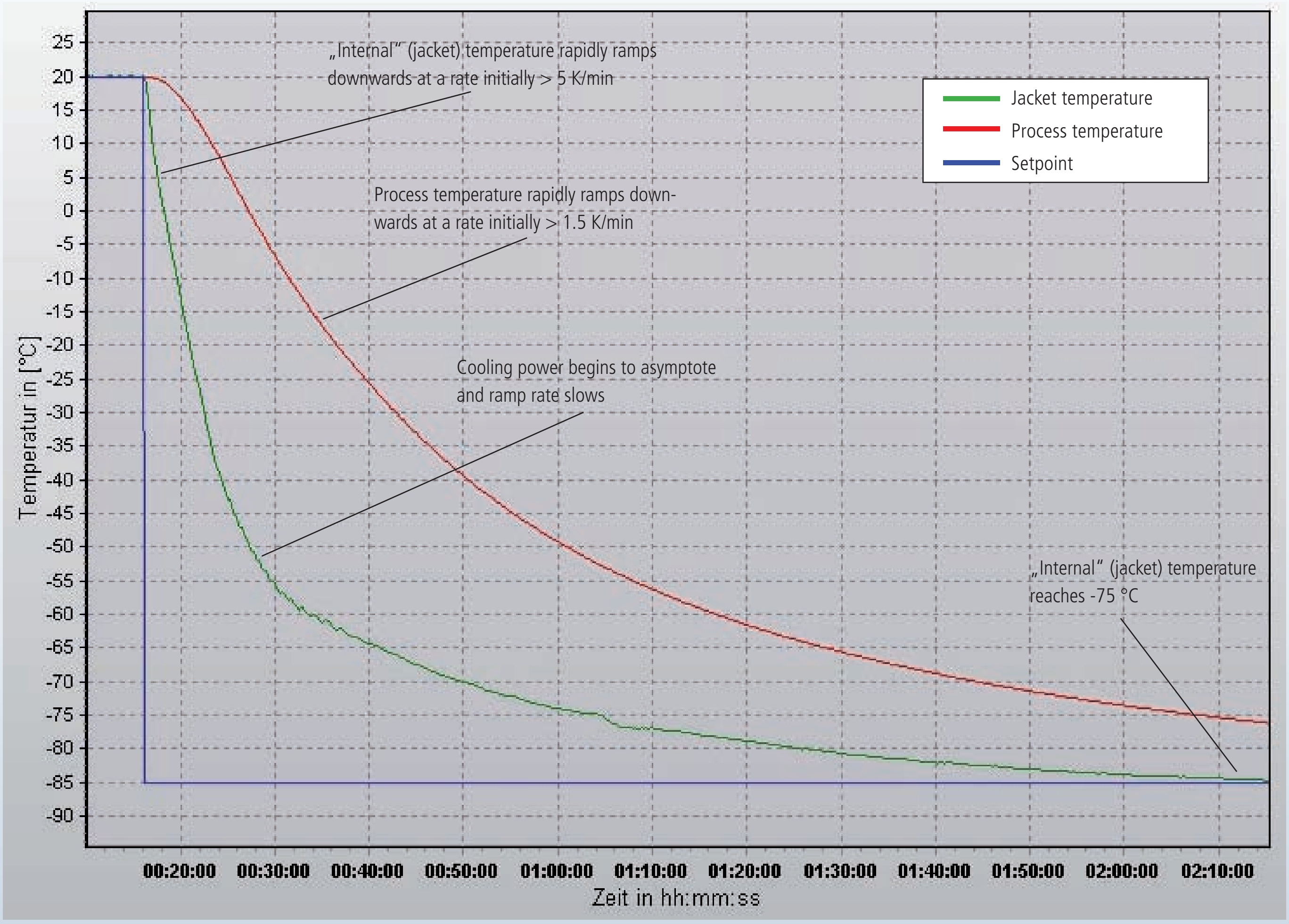
Unistat® 830

Cooling the jacket of a Radleys 10-litre reactor to -76 °C

Requirement
The graphic shows a cooling curve from 20 °C to -85 °C connected to a Radleys 10-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
This 2-hour test shows that the Unistat® 830 can cool the "internal" (jacket) temperature to -76 °C with a resultant process temperature of -66 °C.



Version: 9/2009

Unistat® 830

Controlling a 200 W (172 kcal / hr) exothermic reaction in a Radleys 10-litre jacketed reactor

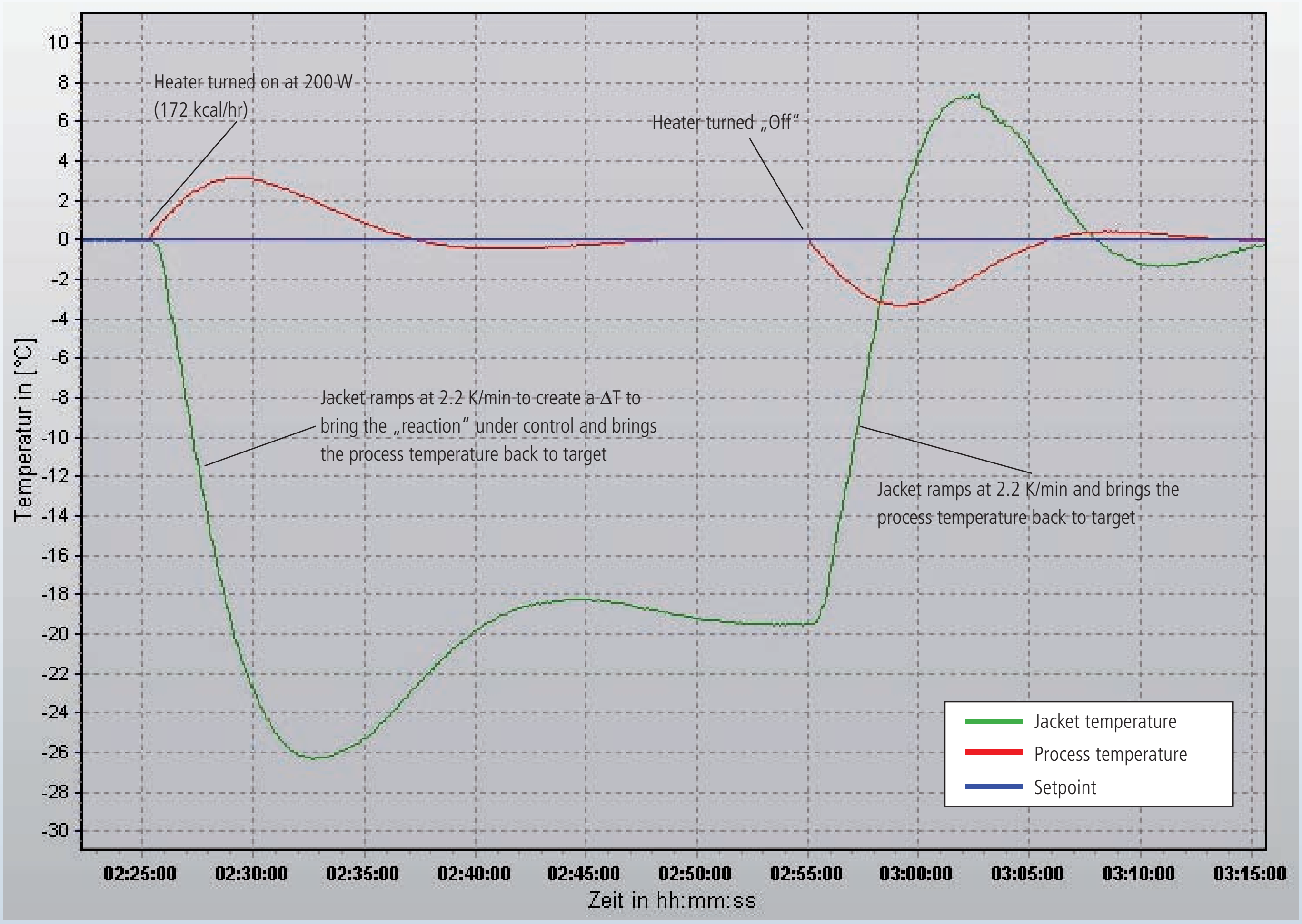
Requirement
The graphic illustrates the dynamic of a Unistat® 830 working with a Radleys 10-litre glass reactor. An exothermic reaction is simulated at 0 °C with a power of 200 W (172 kcal / hr).

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF. The exothermic reactions are simulated using a controlled electric immersion heater.

Results
The heat input results in a temperature rise of approx. 3 K. The internal temperature jumps to approx. -26.3 °C to pull the process temperature back to its initial conditions. In 22 minutes the process temperature recovers to 0 °C.
The heating is then removed from the reactor (at 02:55:00) and the sudden heat loss is compensated in 17 minutes.

Setup details
Unistat® 830 & Radleys reactor

Temperature range:	-85...200 °C
Cooling power:	3.8 kW @ 100 °C 3.6 kW @ 0 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	80 rpm
Control:	process



Setup details
Unistat® 830 & Radleys 10-litre glass reactor

Temperature range:	-85...200 °C
Cooling power:	3.8 kW @ 100 °C
	3.6 kW @ 0 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	80 rpm
Control:	process

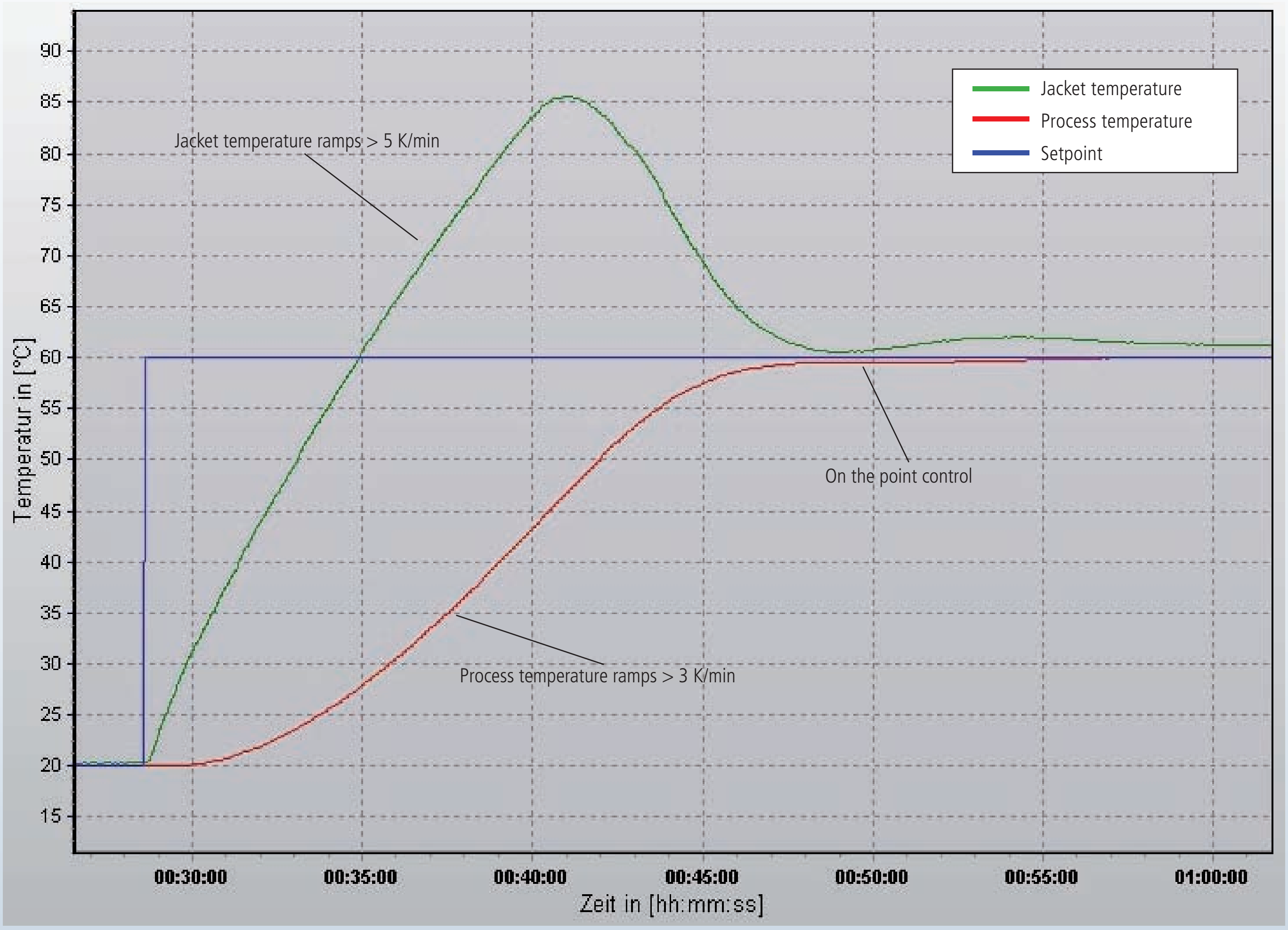
Unistat® 830

CHeating a Radleys 10-litre glass reactor from 20 °C to 60 °C

Requirement
This short test measures the heating time of Unistat® 830 from 20 °C to 60 °C in a Radleys 10-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The internal temperature provides a heating rate of 5.4 K / min to the process. As a result the process temperature reaches 60 °C in 28 minutes.



Version: 9/2009

Unistat® 830

Heating & cooling a Radleys 10-litre jacketed reactor

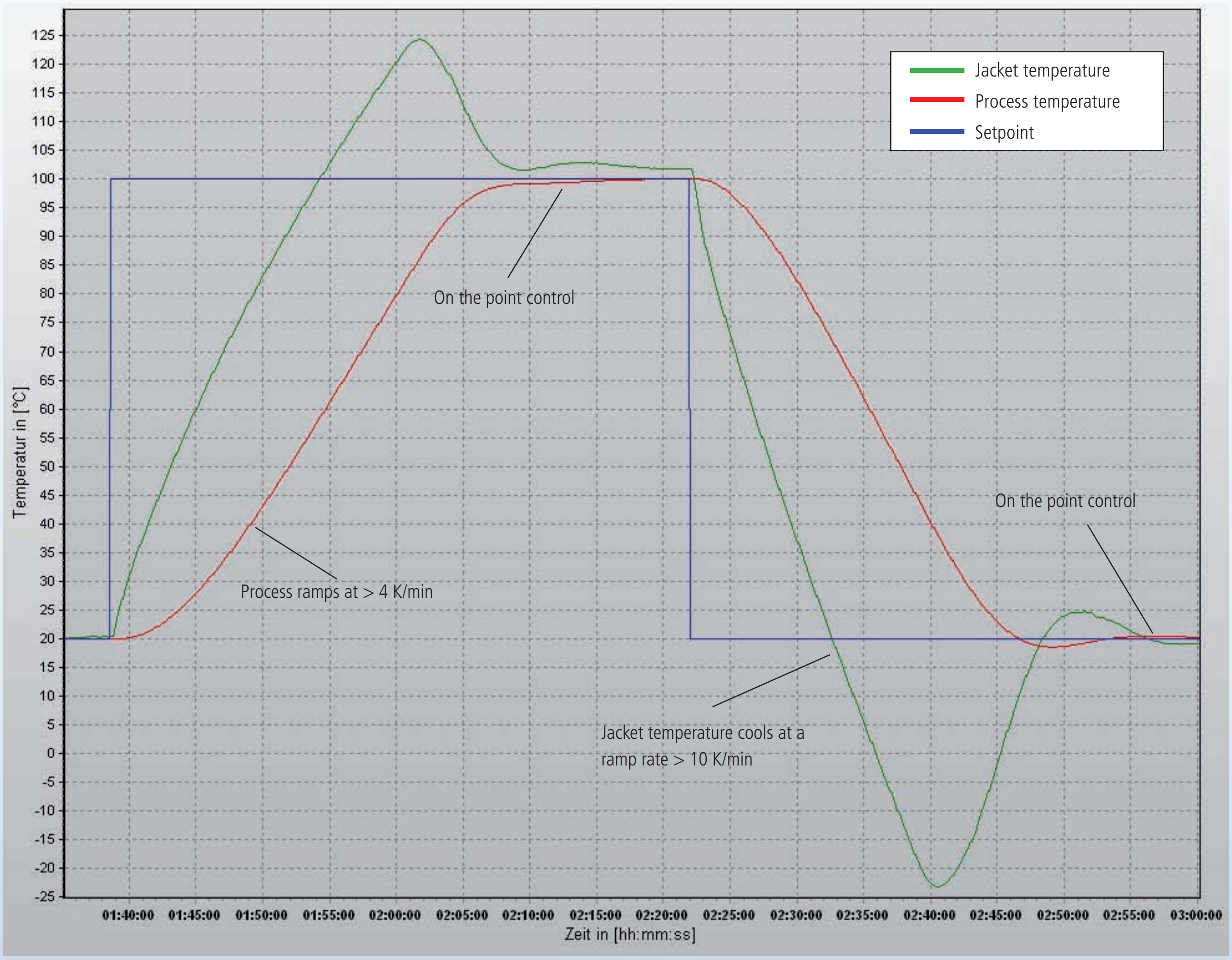
Requirement
The graphic shows the performance of Unistat® 830 working to heat and cool a 10-litre glass reactor between 20 °C to 100 °C and back to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The Unistat® ramps the process through 80 K (20 °C to 100 °C) in approximately 39 minutes. The cooling cycle back to 20 °C takes approximately 38 minutes. In both cases the control is exact with minimal over shoot.

Setup details
Unistat® 830 & Radleys reactor

Temperature range:	-85...200 °C
Cooling power:	3.8 kW @ 100 °C 3.6 kW @ 0 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	80 rpm
Control:	process



Setup details
Unistat® 830 & Radleys reactor

Temperature range:	-85...200 °C
Cooling power:	4.0 kW @ 200 °C 3.8 kW @ 100 °C 3.6 kW @ 0 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor contents:	7.5 litre M90.055.03 (#6259)
Reactor stirrer speed:	80 rpm
Control:	process

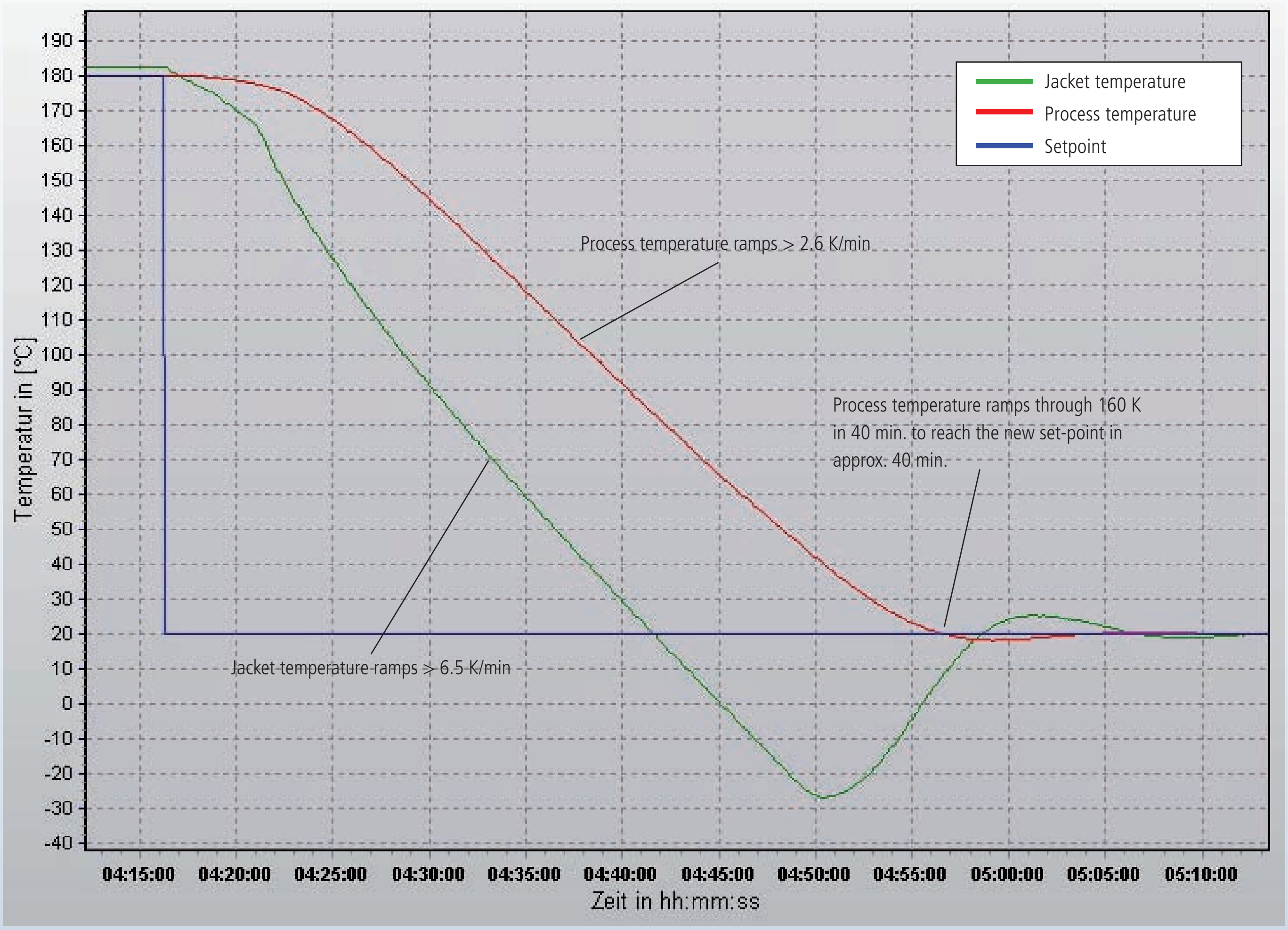
Unistat® 830

Cooling a Radleys 10-litre jacketed reactor from 180 °C to 20 °C

Requirement
The graphic demonstrates the performance of a Unistat® 830 working to control the process temperature inside a Radleys 10-litre reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The internal temperature goes down to approx. -27 °C within 34 minutes. This provides cooling at a rate of 6.5 K / min to the process. The process temperature takes 55 minutes to be fully stable at 20 °C and remains exact and stable at the set-point.



Version: 9/2009

Unistat® 830

Cooling a DDPS 25-litre jacketed glass reactor from 180 °C to 20 °C

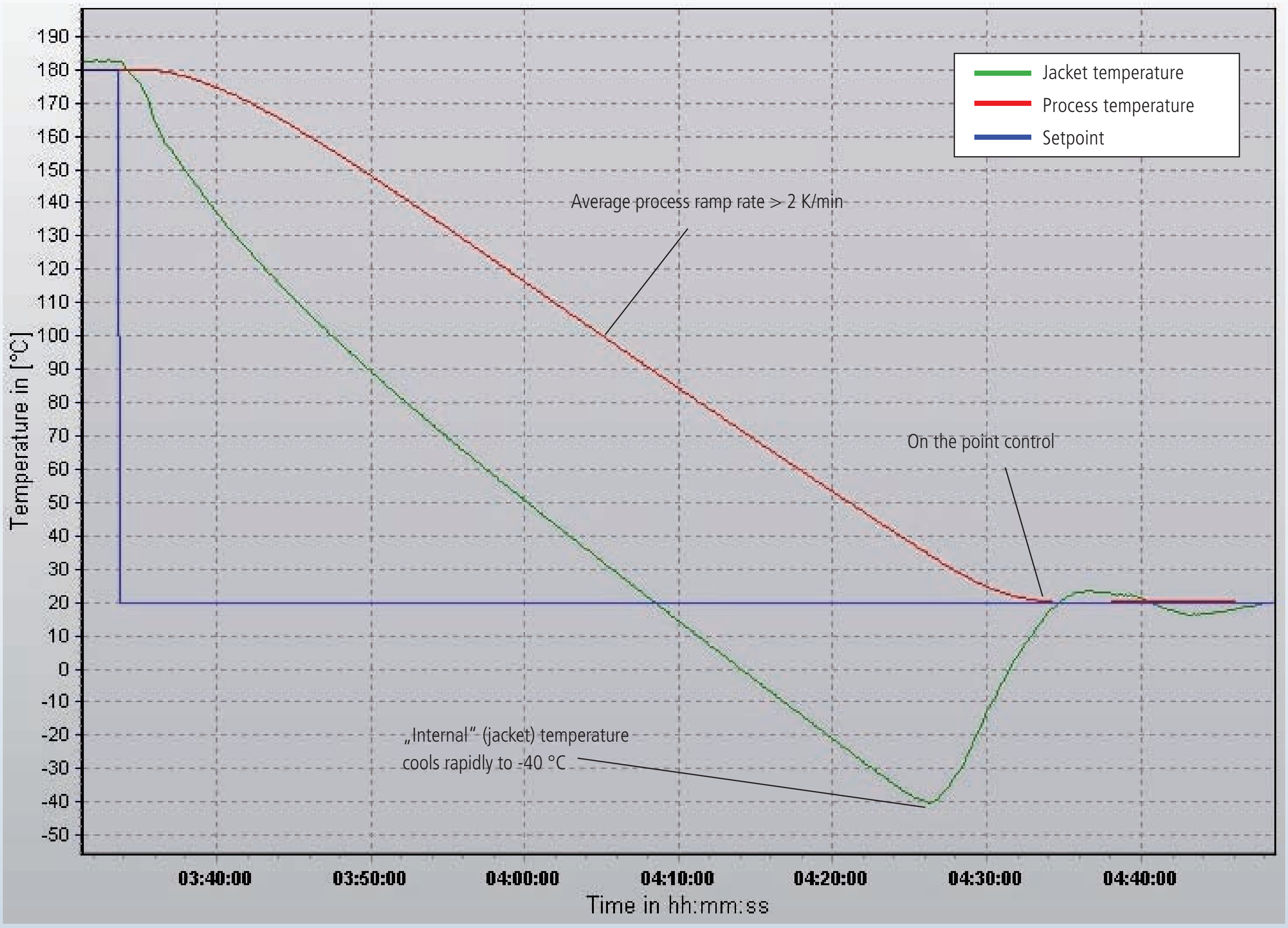
Requirement
The graphic shows the performance of a Unistat® 830 cooling a DDPS 25-litre jacketed glass reactor from 180 °C to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The "internal" (jacket) temperature cools to approx. -40 °C at a ramp rate of 2.86 K / min. As a result the set-point is achieved in 71 minutes.

Setup details
Unistat® 830 & DDPS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated glass reactor
Reactor contents:	18.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process



Setup details
Unistat® 830 & DDPS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated glass reactor
Reactor contents:	18.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process

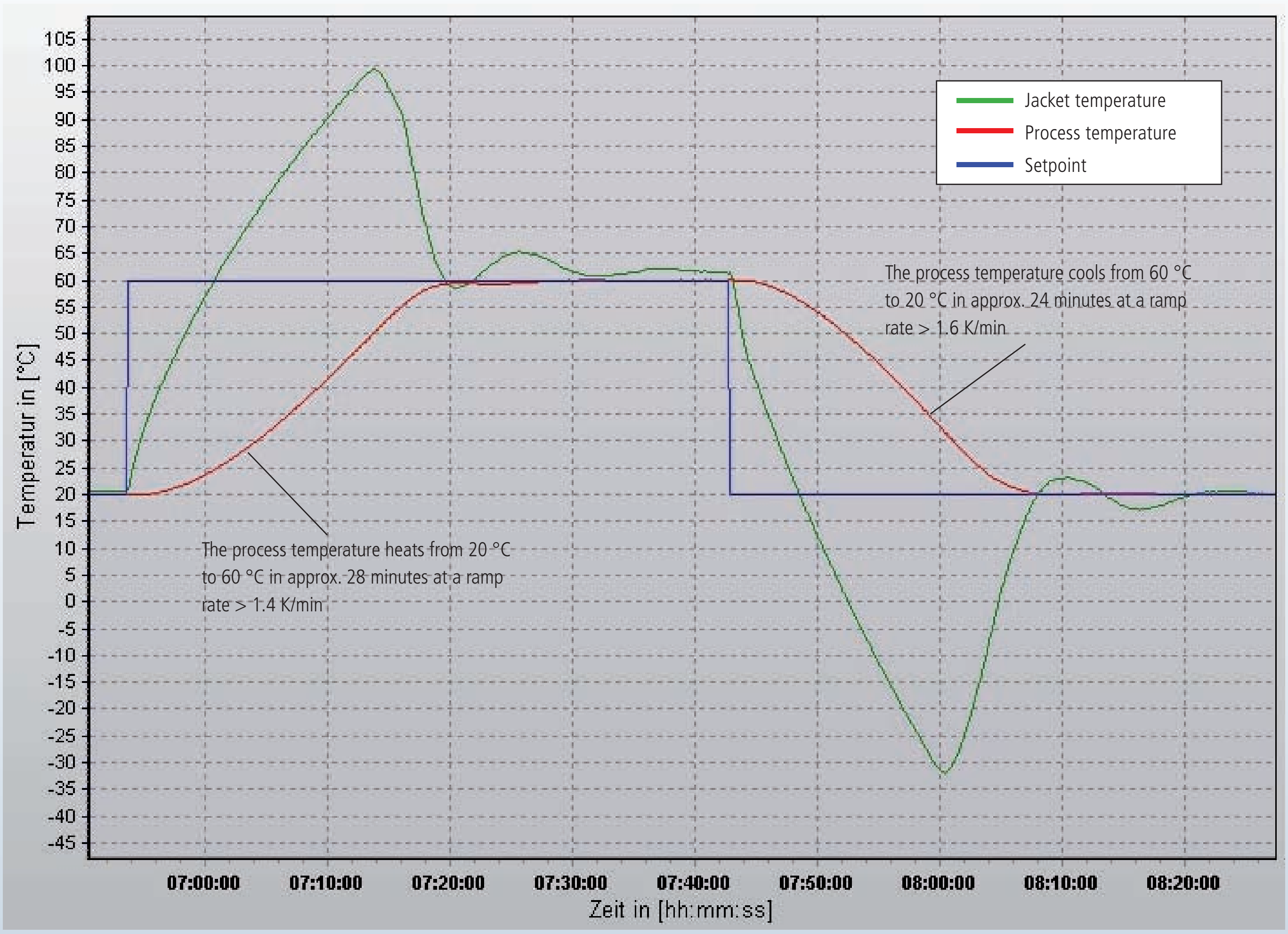
Unistat® 830

Heating and cooling a DDPS 25-litre reactor between 20 °C and 60 °C

Requirement
The case study shows a test result of a Unistat® 830 working to respond to a temperature setpoint change in a 25-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The Unistat® needs approximately 24 minutes to heat the reactor up to 60 °C. The heating rate ramps at approximately at 1.4 K / min at the process temperature curve. On the other hand, the cooling process back to 20 °C takes 24 minutes. This cooling of the process temperature is at a rate of 1.6 K / min.



Version: 9/2009

Unistat® 830

Cooling a 25-litre reactor to T_{min}

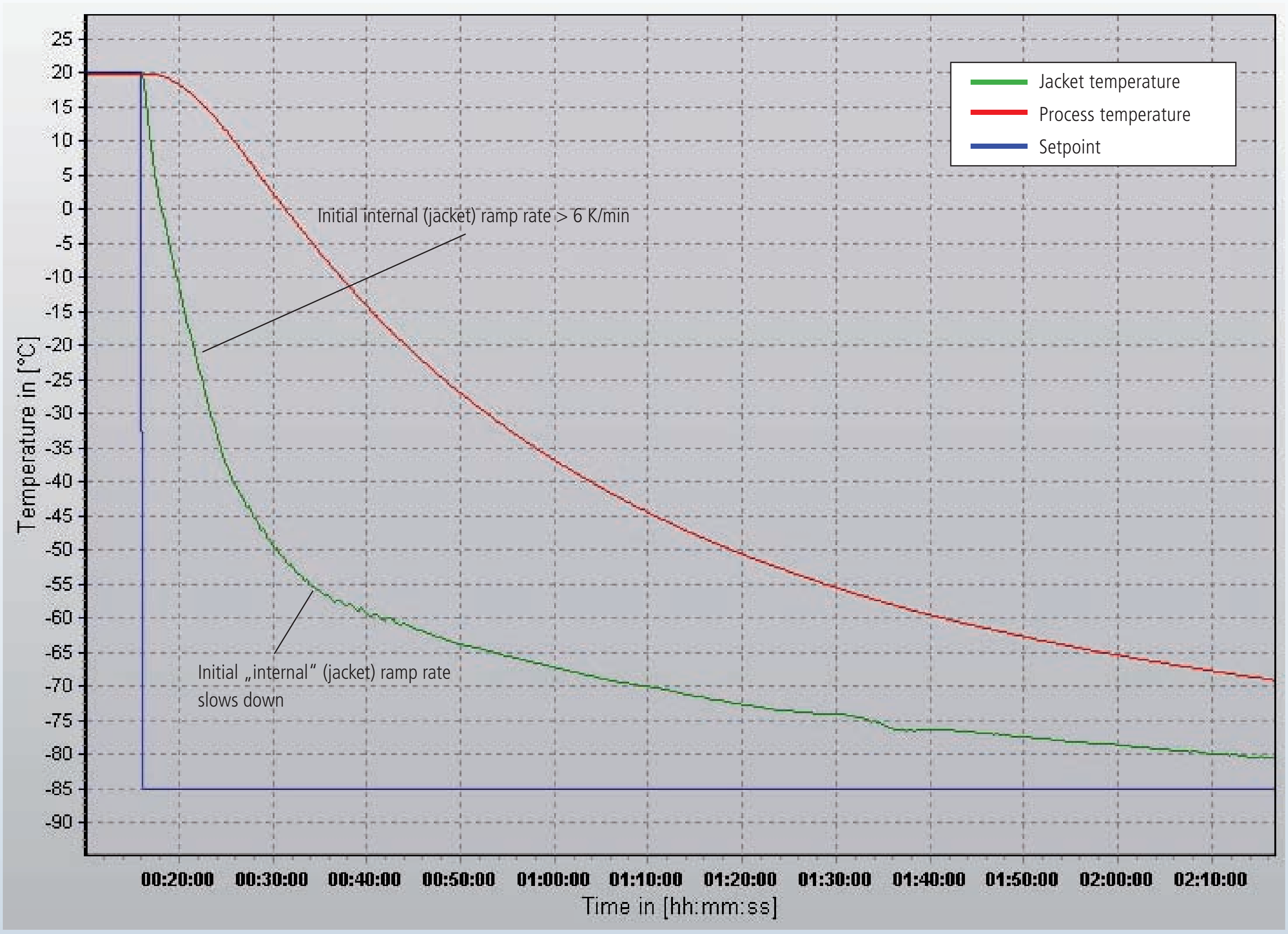
Requirement
The test is performed to investigate the minimum achievable process temperature in a DDPS 25-litre glass reactor when connected to a Unistat® 830.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The graphic demonstrates that the Unistat® is able to pull the "internal" (jacket) temperature to -80 °C with a corresponding process temperature to approximately -69 °C within the test period.

Setup details
Unistat® 830 & DDPS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated glass reactor
Reactor contents:	18.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process



Setup details
Unistat® 830 & DDPS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C
	2.2 kW @ -60 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vaccum insulated jacketed glass reactor
Reactor contents:	18.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	internal

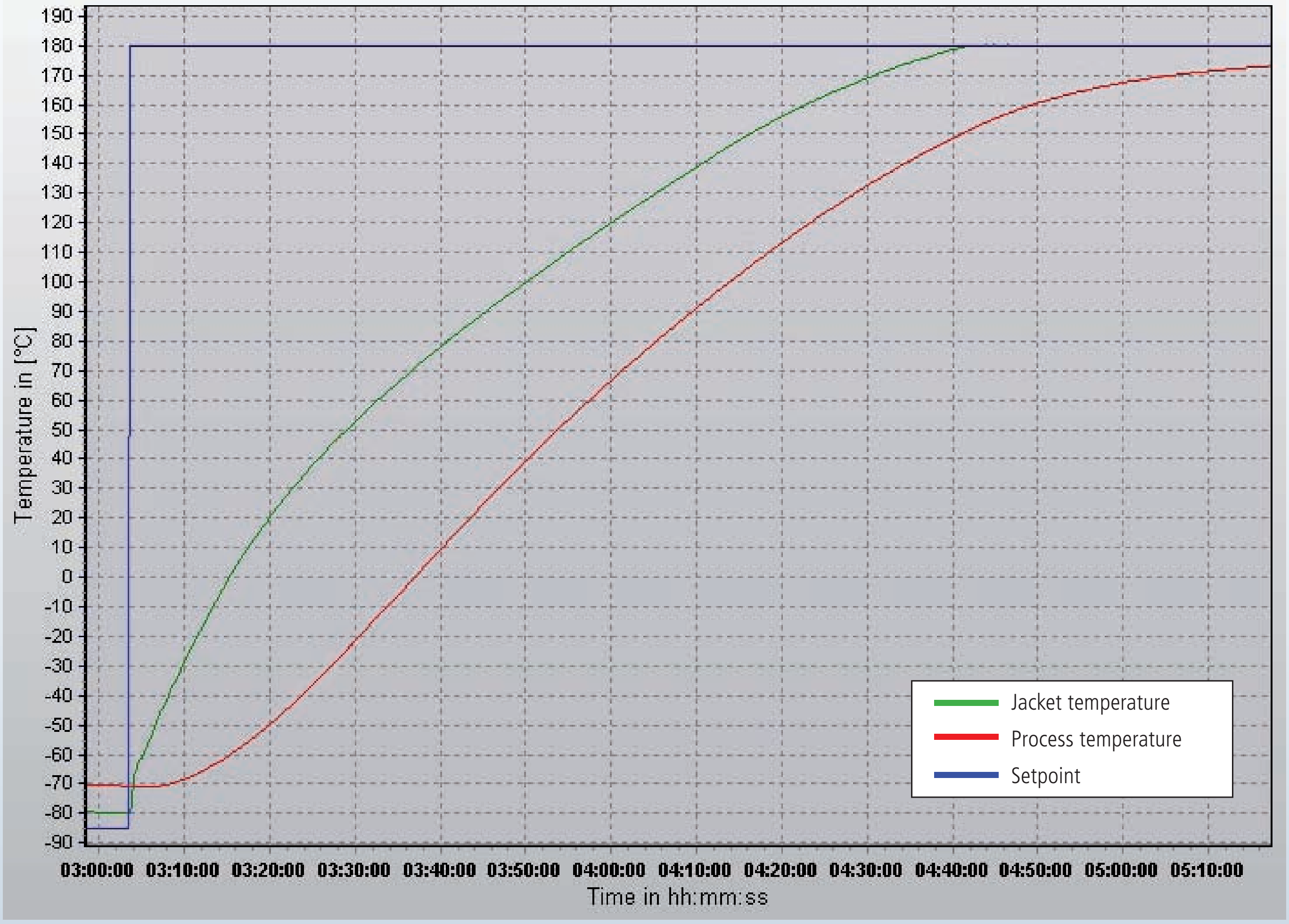
Unistat® 830

Jacket heating from -80 °C to 180 °C in a DDPS 25-litre reactor

Requirement
A simple test is conducted to measure the time taken by the Unistat® 830 to heat the DDPS's reactor's jacket from -80 °C to 180 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
With a heating power of 3.0 kW the Unistat® takes under 1 hour 40 minutes to ramp through 260 K.



Version: 9/2009

Unistat® 830

Heating a DDPS 25-litre glass reactor

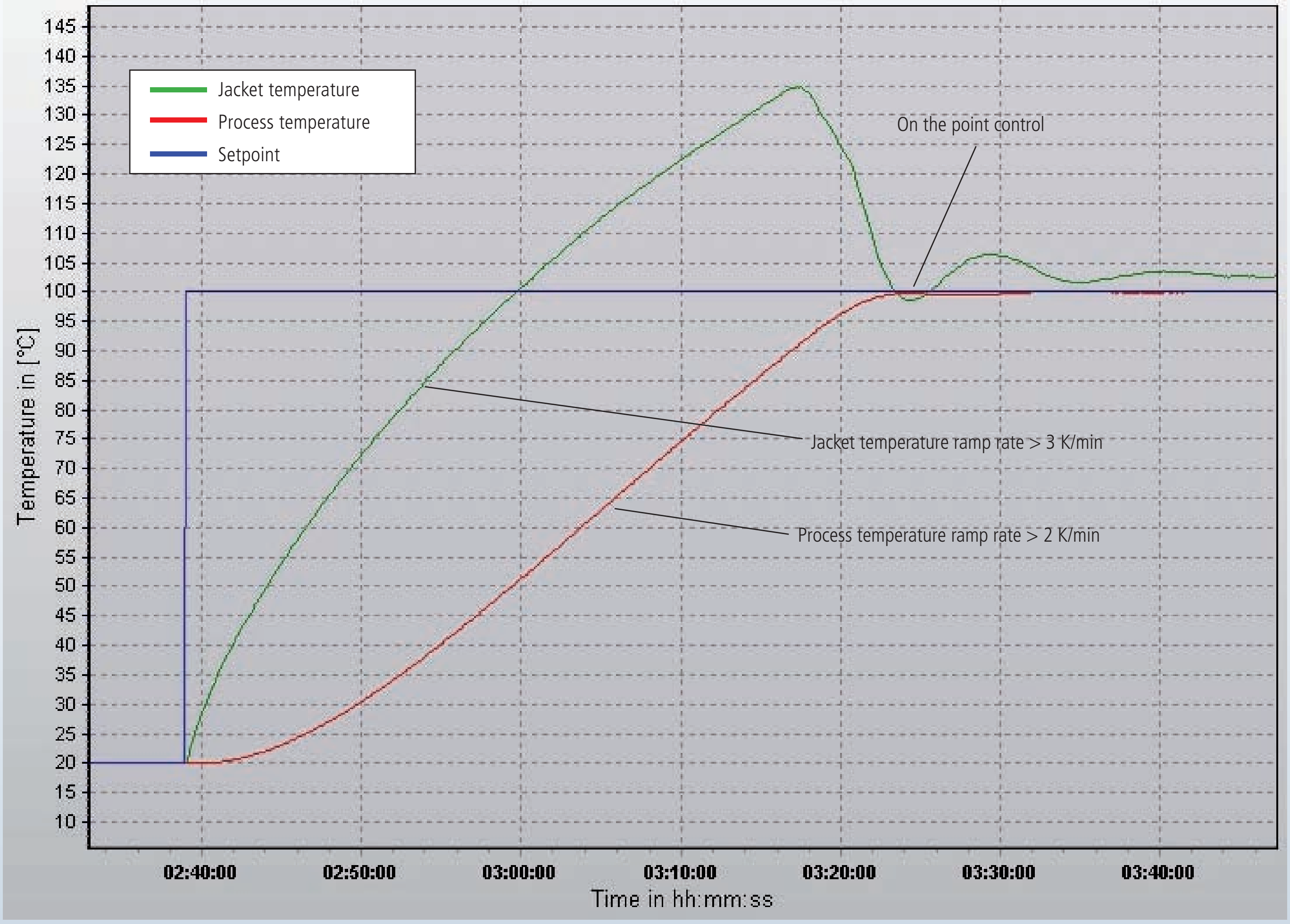
Requirement
The diagram shows the temperature profile of a Unistat® 830 working with a DDPS 25-litre reactor within a temperature range from 20 to 100 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The Unistat® takes 28 minutes to heat the process temperature up to 100 °C an average ramp rate > 2 K / min and the jacket temperature > 3 K / min.

Setup details
Unistat® 830 & DDPS reactor

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 0 °C 2.2 kW @ -60 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated glass reactor
Reactor contents:	18.75 litre M90.055.03 (#6259)
Reactor stirrer speed:	70 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	3.5 kW @ -20…-40 °C 2.2 kW @ -60 °C 0.7 kW @ -80 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	20 litre un-insulated jacketed metal pressure reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	internal

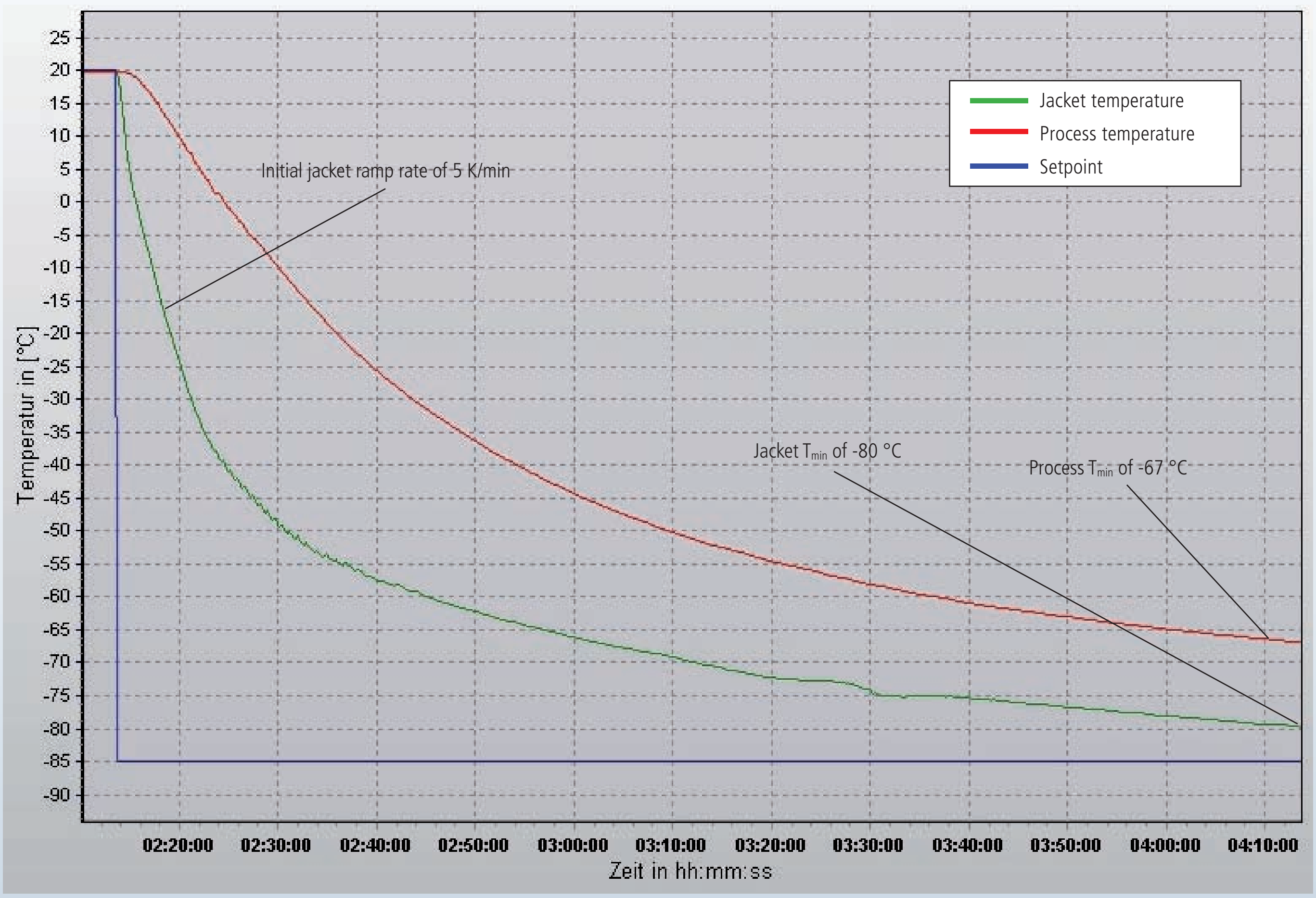
Unistat® 830

Cooling a Büchi 20-litre metal reactor to T_{min}

Requirement
This case study looks at the performance of a Unistat® 830 cooling a 20-litre metal reactor to T_{min} under "internal" (jacket) control.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The initial ramp rate from 20 °C to -40 °C (60 K) over approximately 12 minutes (a ramp rate of 5 K / min) is almost linear before the cooling power begins to asymptote and the ramp rate slows. After 2 hours the "internal" (jacket) temperature reaches -80 °C with a corresponding process temperature of -67 °C. Both temperatures continue to trend lower but with a slowing ramp rate.



Version: 9/2009

Unistat® 830

Heating and cooling a 20-litre metal jacketed reactor under different control dynamics

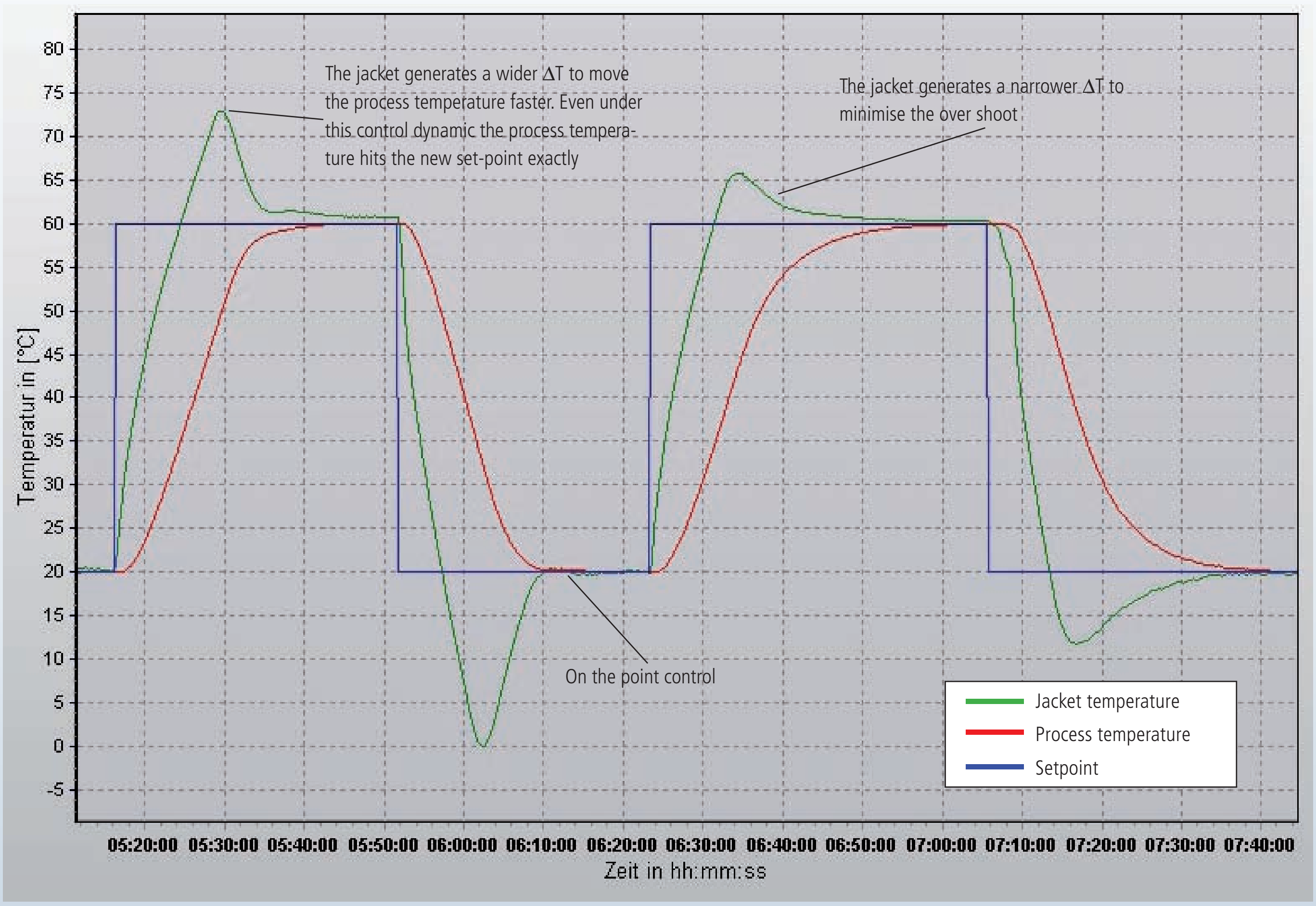
Requirement
A standard feature of the "Unistat®-Pilot" is to choose "fast, small overshoot" or "without overshoot" when reaching a set-point.
The graphic shows the differences in performance between these settings. In this test the Unistat® 830 is programmed to alternate between 20 °C and 60 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The first process curve (fast, small overshoot) reaches 60 °C in just 22 minutes with the second process curve (without overshoot) takes 35 minutes to reach the same set-point temperature.
It can be seen that the overshoot is very minimal in the "fast, small overshoot" mode.

Setup details
Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 100 °C 3.5 kW @ 0 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed un-insulated metal pressure reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process



Version: 9/2009

Unistat® 830

Cooling a Büchi 20-litre metal reactor from 100 °C to 20 °C

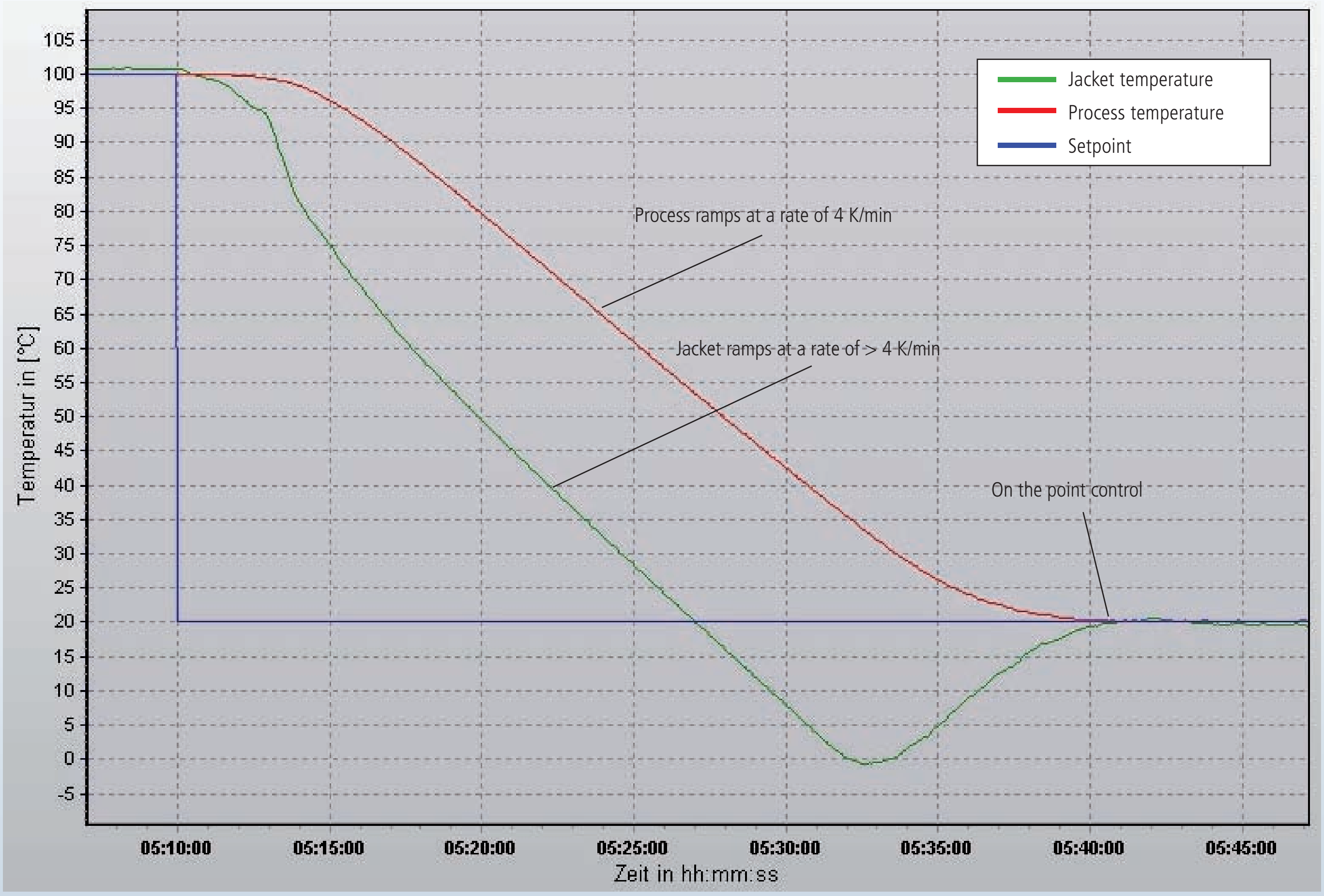
Setup details
Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	3.6 kW @ 100 °C 3.5 kW @ 0 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	20 litre un-insulated jacketed metal pressure reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process

Requirement
This case study looks at the performance of a Unistat® 830 cooling a Büchi 20-litre metal jacketed reactor from 100 °C to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process temperature cools smoothly and exactly to its new set-point of 20 °C after ramping through 80 K (100 °C to 20 °C).



Version: 9/2009

Unistat® 830

Heating & cooling a 20-litre metal jacketed reactor between 20 °C and 180 °C

Requirement

This case study is to look at the performance of a Unistat® 830 heating and cooling a 20-litre metal jacketed reactor from 20 °C to 180 °C and back to 20 °C.

Method

The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

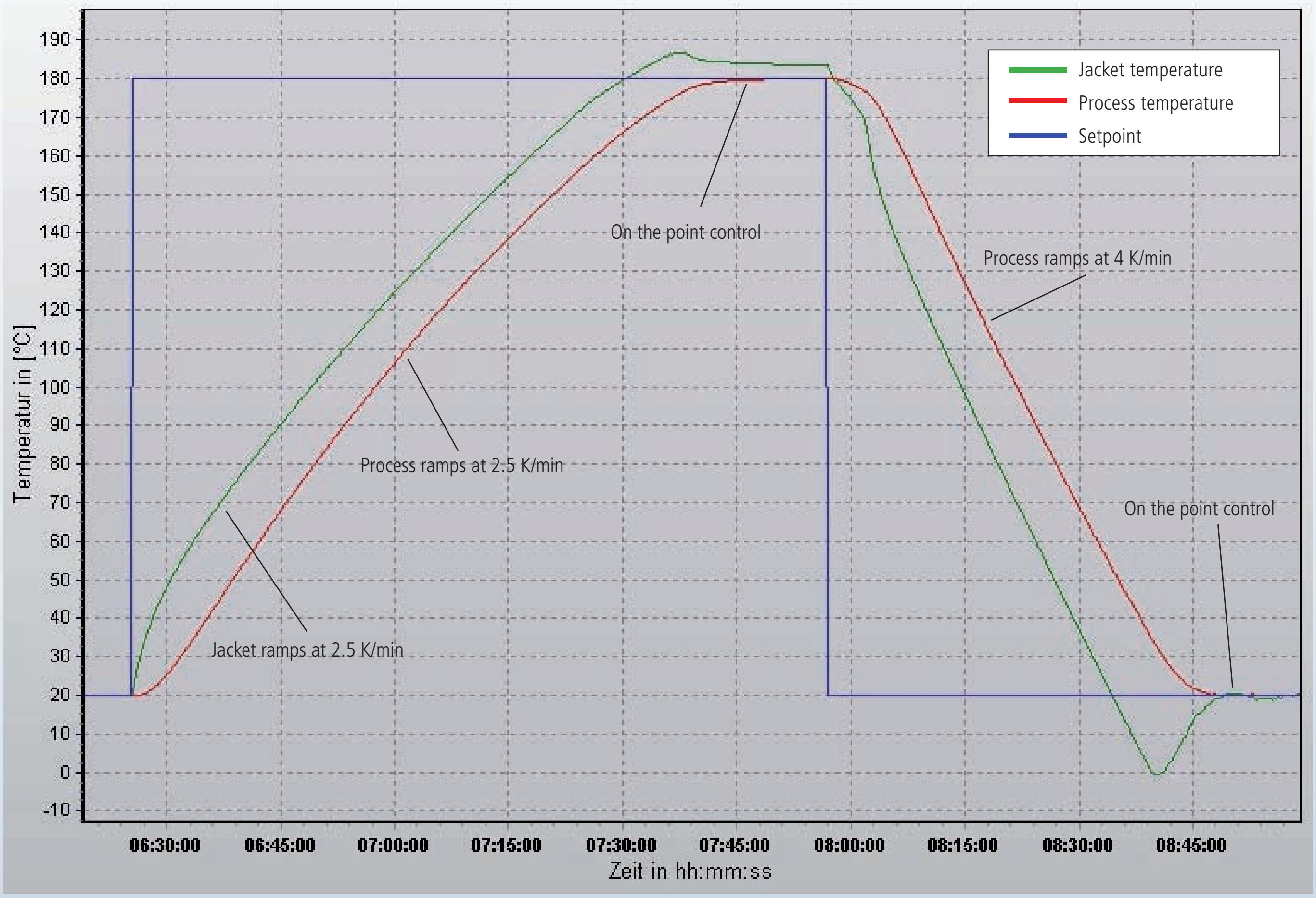
Results

The HTF used is DW-Therm which has a maximum temperature of 200 °C. It can be seen that the unit prevents the DW-Therm from exceeding its limits while still accurately controlling the process to its new set-point.

Setup details

Unistat® 830 & Büchi reactor (büchiglasuster)

Temperature range:	-85...200 °C
Cooling power:	4.0 kW @ 200 °C 3.8 kW @ 100 °C 3.5 kW @ 0 °C
Heating power:	3 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	20 litre un-insulated jacketed metal pressure reactor
Reactor contents:	15 litre M90.055.03 (#6259)
Reactor stirrer speed:	400 rpm
Control:	process



Setup details
Unistat® 910w & Chemglass reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	50 litre un-insulated jacketed glass reactor
Reactor content:	35 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process

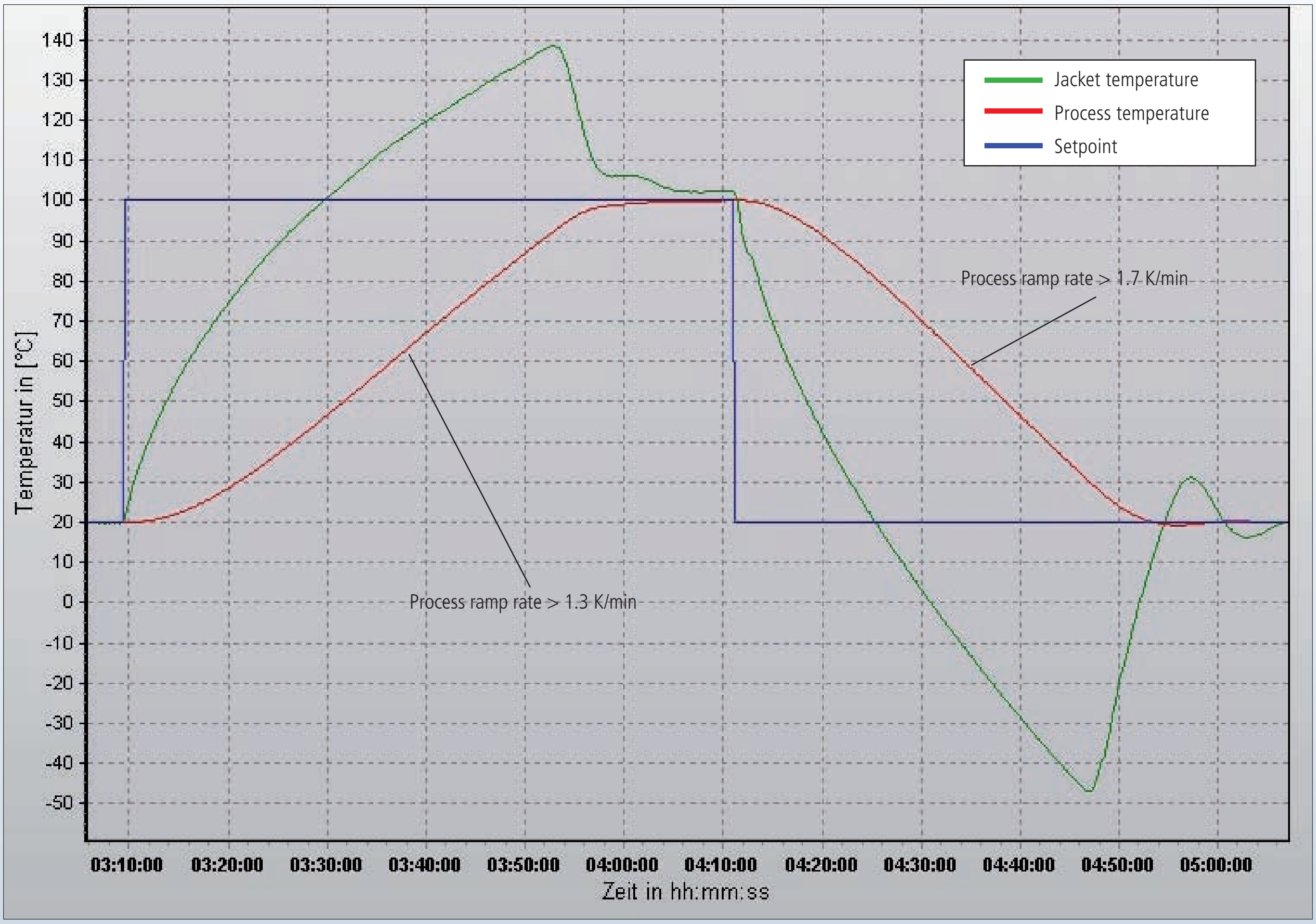
Unistat® 910w

Heating and cooling a Chemglass 50-litre un-insulated glass reactor

Requirement
The graphic shows the performance of a Unistat® 910w connected to an un-insulated 50 litre reactor with M30x1.5 hoses.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 35 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
From a starting temperature of 20 °C, the purpose of the test is to illustrate the ramp speed of the process temperature in response to setpoint of 100 °C and then back to 20 °C.
The process temperature reaches 100 °C from 20 °C within 53 minutes (ramp rate > 1.3 K / min). The cooling ramp-rate is > 1.7 K / min reaching 20 °C from 100 °C in 47 minutes.



Version: 9/2009

Unistat® 910w

Heating a 50-litre jacketed glass reactor from -50 °C to 20 °C

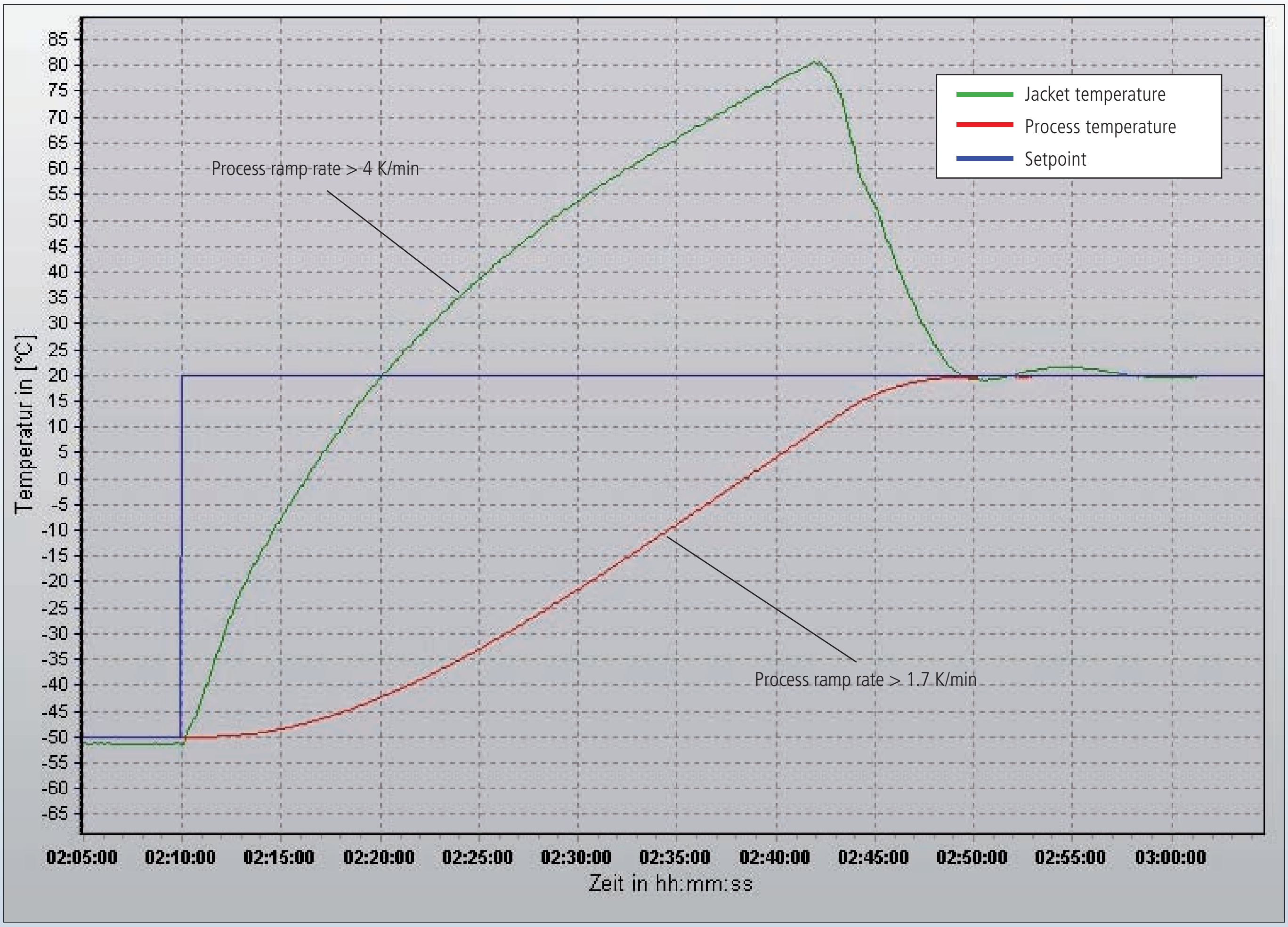
Requirement
This case study demonstrates the response of Unistat® 910w to heat the contents of an un-insulated 50-litre glass reactor from -50 °C to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 35 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process temperature is ramped rapidly to set-point with a negligible overshoot and achieving stability within 40 minutes.

Setup details
Unistat® 910w & Chemglass reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	50 litre un-insulated jacketed glass reactor
Reactor content	35 litre M90.055.03 (#6259)
Stirrer speed	80 rpm
Control	process



Version: 9/2009

Setup details
Unistat® 910w & Radleys reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content	7.5 litre M90.055.03 (#6259)
Stirrer speed	80 rpm
Control	process

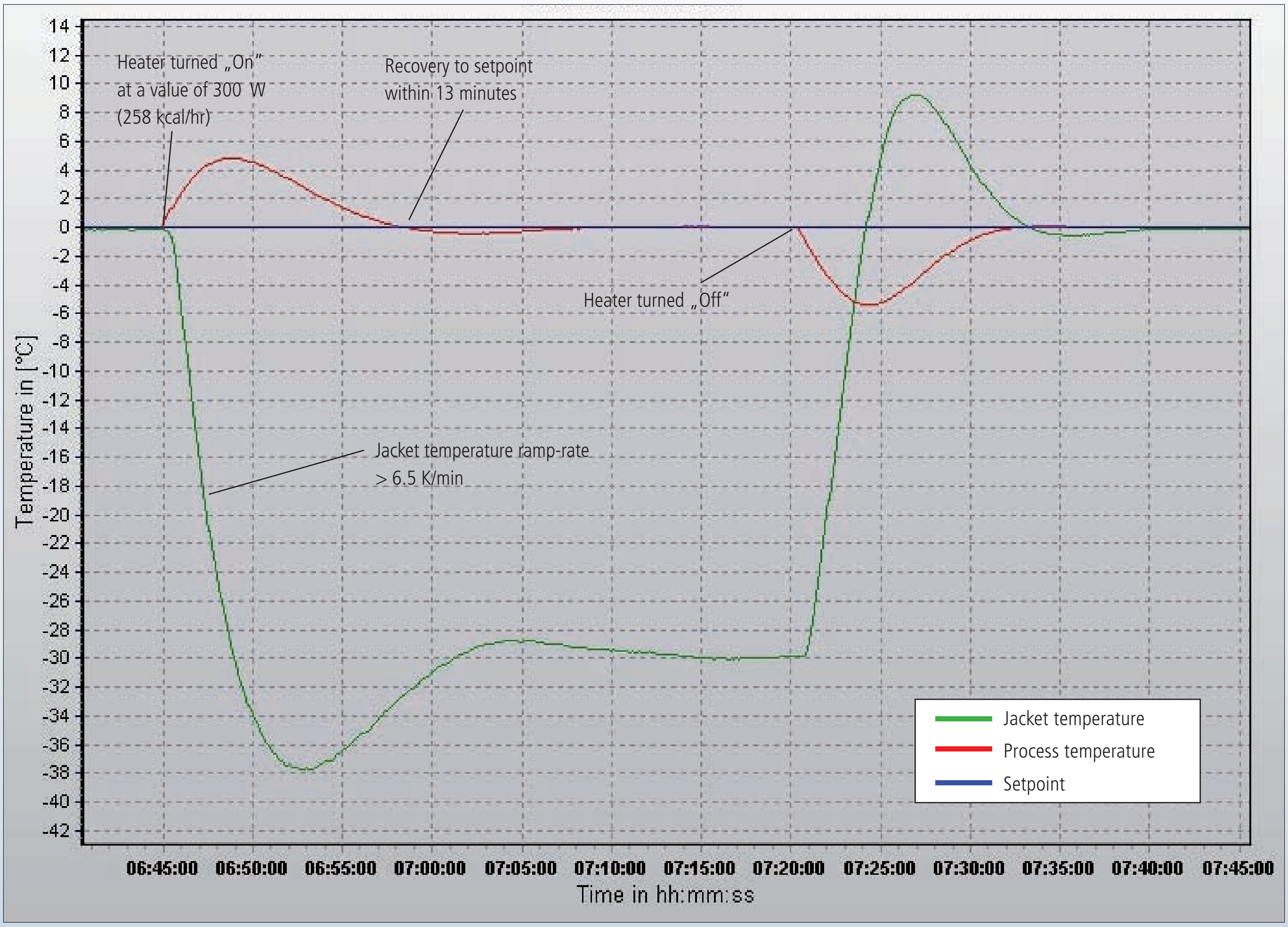
Unistat® 910w

300W (258 kcal / hr) exothermic reaction Radleys 10-litre jacketed reactor

Requirement
A 300 W (258 kcal / hr) exothermic reaction is simulated at 0 °C using an electric heater inside a Radleys 10-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF. The exothermic reactions are simulated using a controlled electric immersion heater.

Results
The process temperature rise to approx. 5 °C as the jacket temperature cools to approx. -38 °C in order to remove the heat generated by the simulated exothermic reaction. This cools the process temperature at a rate of 5.4 K / min. As a result the process temperature recovers to target in approximately 13 minutes.
When the heater is turned off removing the extra heat, the process cools but is rapidly returned to the set-point.



Version: 9/2009

Unistat® 910w

Cooling a Büchi 20-litre reactor to "T_{min}"

Requirement

This case study is to find the minimum temperature that a Unistat® 910w can take the jacket and the resultant process temperature of a Büchi 20-litre glass reactor.

Method

The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results

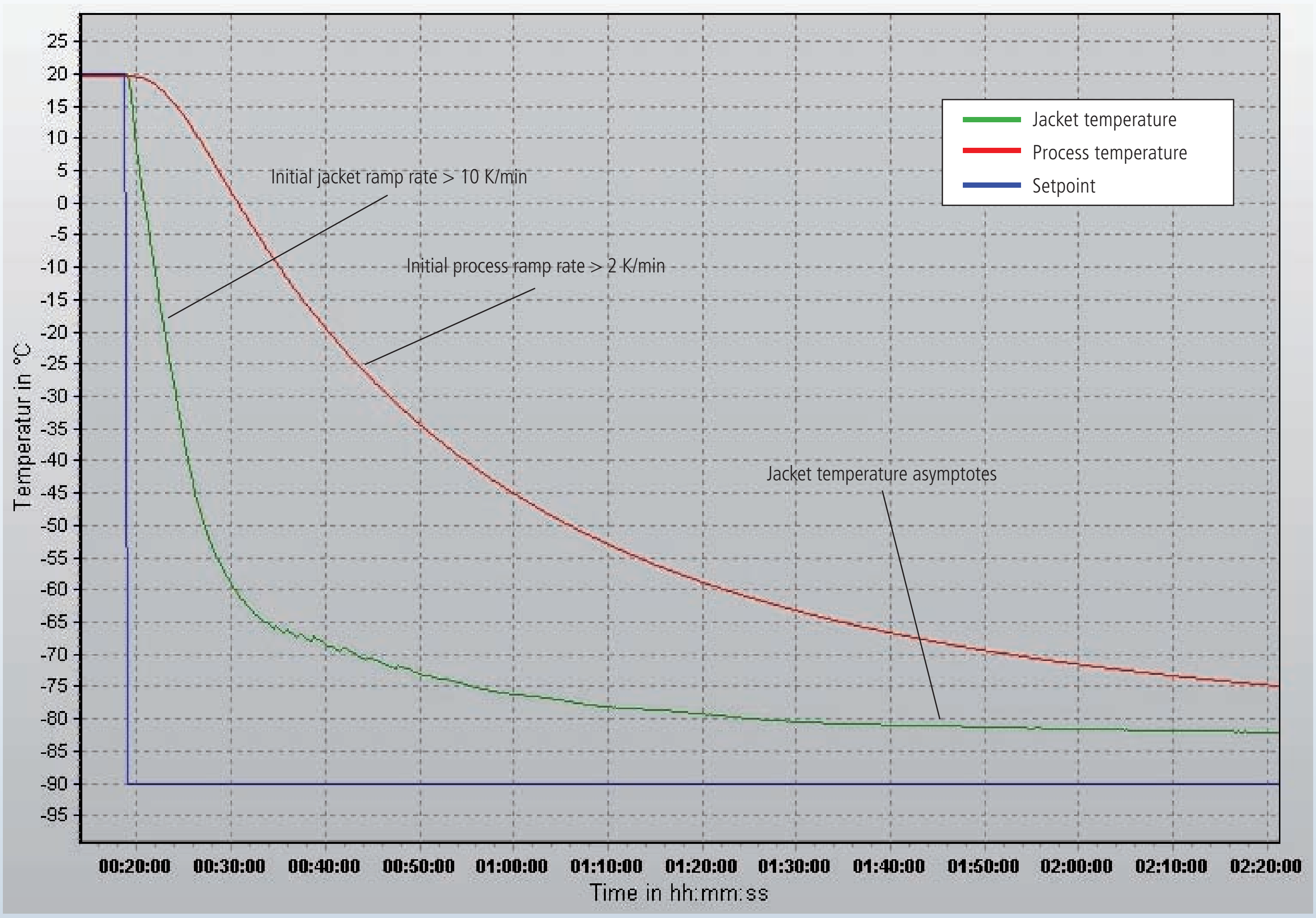
Initially the jacket temperature ramps at a rate of 11 K / min and begins to asymptote between -60 °C and -65 °C and finally bottoming out at -82 °C.

The minimum resultant process temperature is around -75 °C. If the test was allowed to run on this would probably have cooled another degree or so.

Setup details

Unistat® 910w & Büchi reactor (büchiglasuster)

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C 3.1 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre un-insulated jacketed glass reactor
Reactor content:	15 litre M90.055.03 (#6259)
Stirrer speed:	70 rpm
Control:	internal



Version: 9/2009

Unistat® 910w

Controlling exothermic reactions in a Büchi 20-litre glass reactor

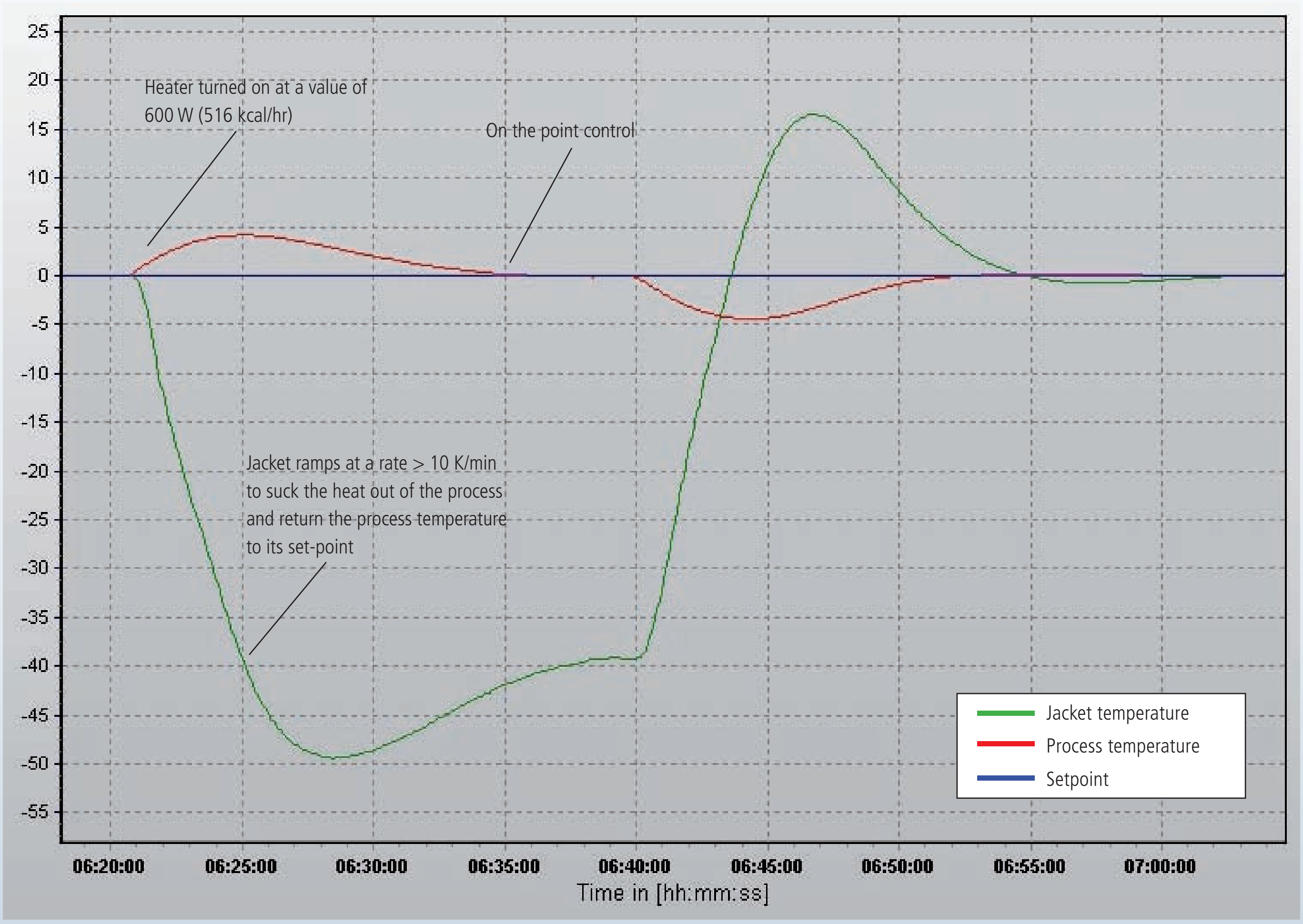
Setup details
Unistat® 910w & Büchi reactor (büchiglasuster)

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content:	15 litre M90.055.03 (#6259)
Stirrer speed:	70 rpm
Control:	process

Requirement
This case study looks at how well a Unistat® 910w controls a simulated 600 W (516 kcal / hr) exothermic reaction in a Büchi 20-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF. The exothermic reactions are simulated using a controlled electric immersion heater.

Result
The response of the Unistat® 910w to a sudden increase in temperature caused by the heat from the simulated exothermic is rapid as the jacket is cooled to -49 °C from 0 °C in around 7 minutes. The process temperature is pulled back to its set-point exactly and held stable.
Once the heater is turned off the Unistat® 910w again responds to return the falling process temperature to its set-point by ramping through 56 K (-39 °C to 17 °C) in 7 minutes.



Version: 9/2009

Unistat® 910w

Cooling a 20-litre jacketed glass reactor from 20 °C to -60 °C then to T_{min}

Requirement

This case study looks at the performance of a Unistat® 910w cooling a Büchi 20-litre glass reactor first to -60 °C and then to T_{min} under "process" control.

Method

The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

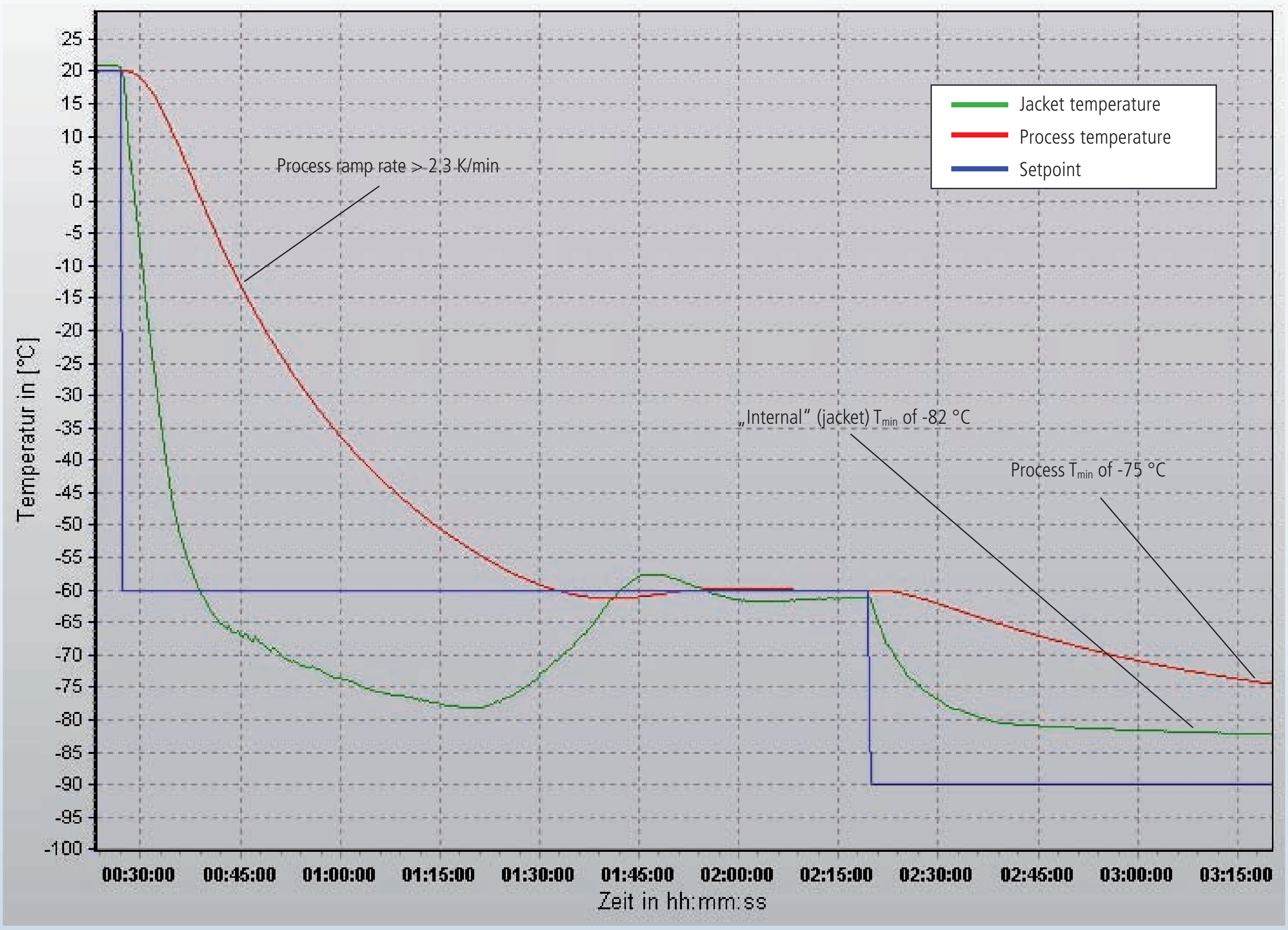
Results

The initial „internal" (jacket) ramp rate is over 6.5 K / min and cools the jacket to -60 °C in less than 10 minutes with a corresponding process ramp rate of 2.3 K / min.
Once the target of -60 °C is reached and temperatures stable the set-point is changed. After 1 hour it can be seen that T_{min} for the jacket is -82 °C with a corresponding process temperature of -75 °C.

Setup details

Unistat® 910w & Büchi reactor (büchiglasuster)

Temperature range:	-90...250 °C
Cooling power:	4.7 kW @ -40 °C 3.1 kW @ -60 °C 0.9 kW @ -80 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content:	15 litre M90.055.03 (#6259)
Stirrer speed:	70 rpm
Control:	process



Setup details
Unistat® 910w & Büchi reactor (büchiglasuster)

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C
Heating power:	6.0 kW
Hoses:	2x 1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content	15 litre M90.055.03 (#6259)
Stirrer speed	70 rpm
Control	process

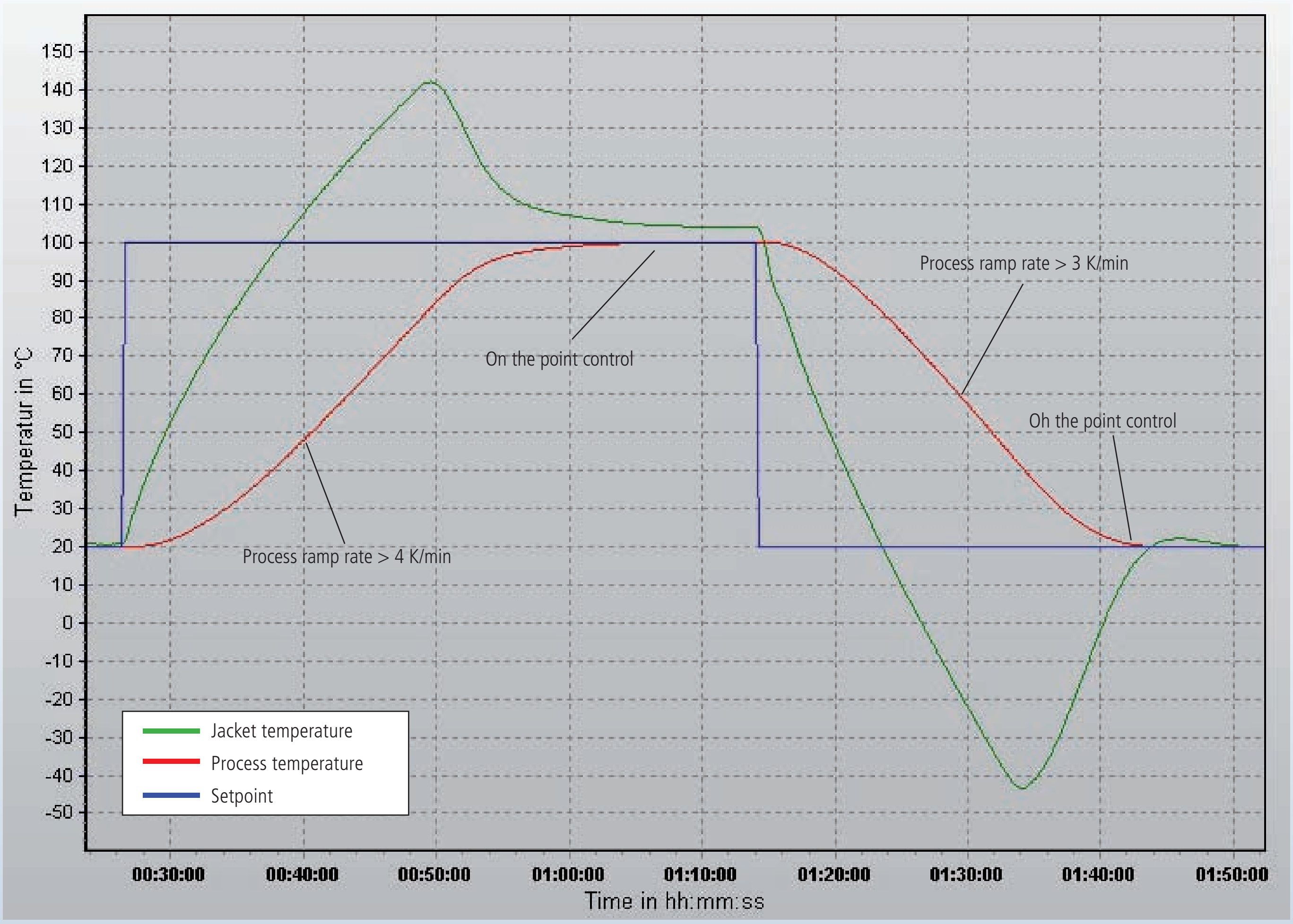
Unistat® 910w

Heating & cooling a Büchi 20-litre jacketed glass reactor from 20 °C to 100 °C to 20 °C

Requirement
This case study looks at the performance of a Unistat® 910w heating and cooling a Büchi 20-litre jacketed glass reactor between 20 °C to 100 °C and back to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
Under process control the jacket temperature ramps rapidly in order to ramp the process to its set-point as quickly as possible. In the cooling cycle it can be seen that the jacket cools to -42 °C from 100 °C (142 K) to pull the process back to 20 °C within 15 minutes (which is a ramp rate of 9.5 K/min!) before ramping back to guide the process to its set-point with no under shoot.



Version: 9/2009

Unistat® 910w

Heating and cooling a 20-litre jacketed glass reactor from 20 °C to 180 °C to 20 °C

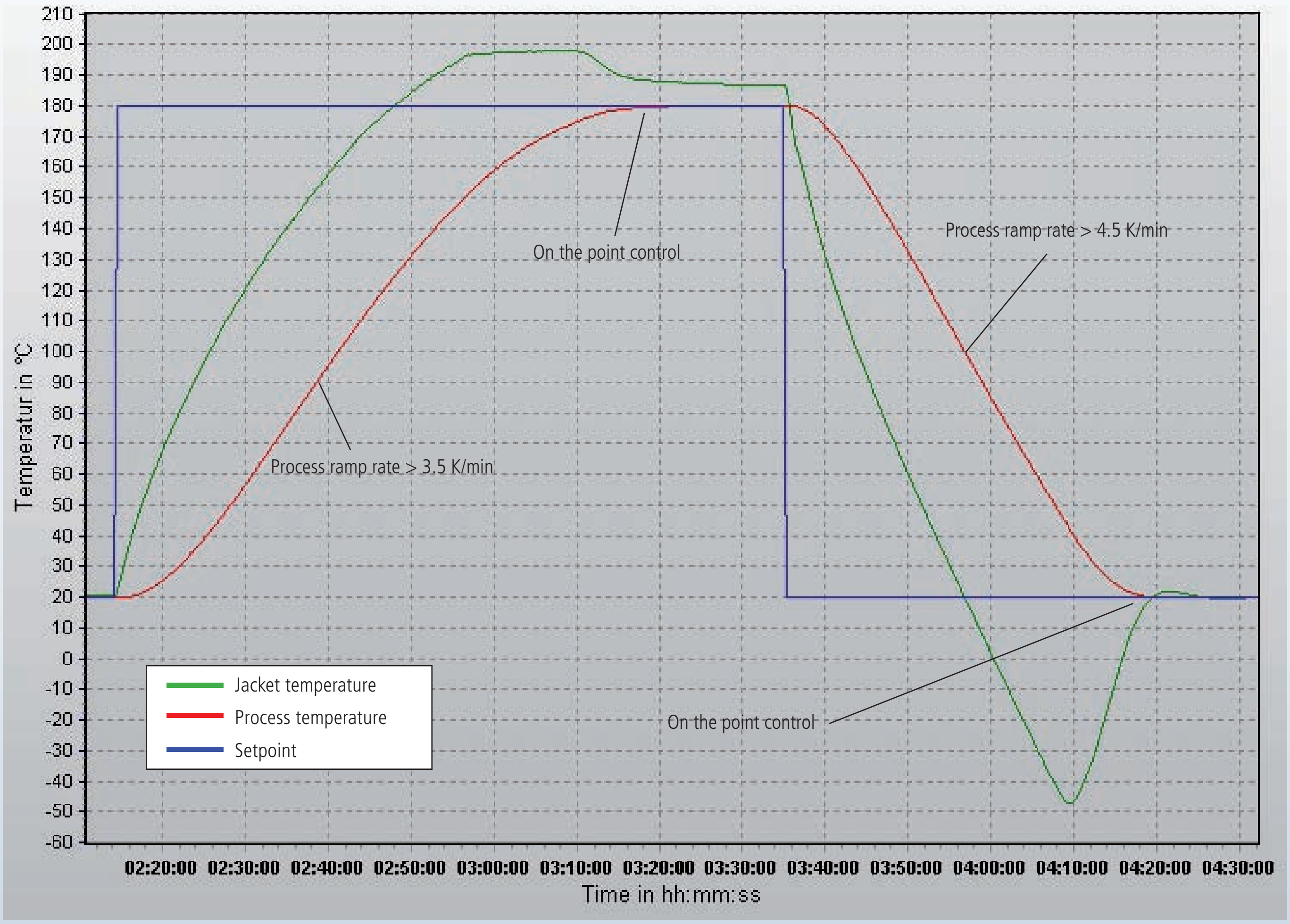
Requirement
This case study looks at the performance of a Unistat® 910w heating and cooling a 20-litre jacketed reactor from 20 °C to 180 °C and back to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 15 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
Because the maximum temperature of DW-Therm (the chosen HTF) the „internal" (jacket) temperature is limited to 200 °C. This limit can be seen at the top of the heating curve as the „internal" (jacket) temperature runs "flat" at just below 200 °C.
Under "process" control the jacket is ramped rapidly to drag the process to its new set points as quickly as possible. It can be seen that in the cooling curve the jacket ramps to -48 °C from 188 °C (236 K) within 32 minutes at a ramp rate > 5.7 K / min.

Setup details
Unistat® 910w & Büchi reactor (büchiglasuster)

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	20 litre jacketed glass reactor
Reactor content	15 litre M90.055.03 (#6259)
Stirrer speed	70 rpm
Control	process



Unistat® 910w

Minimum and maximum temperature with a Radleys 10-litre glass reactor

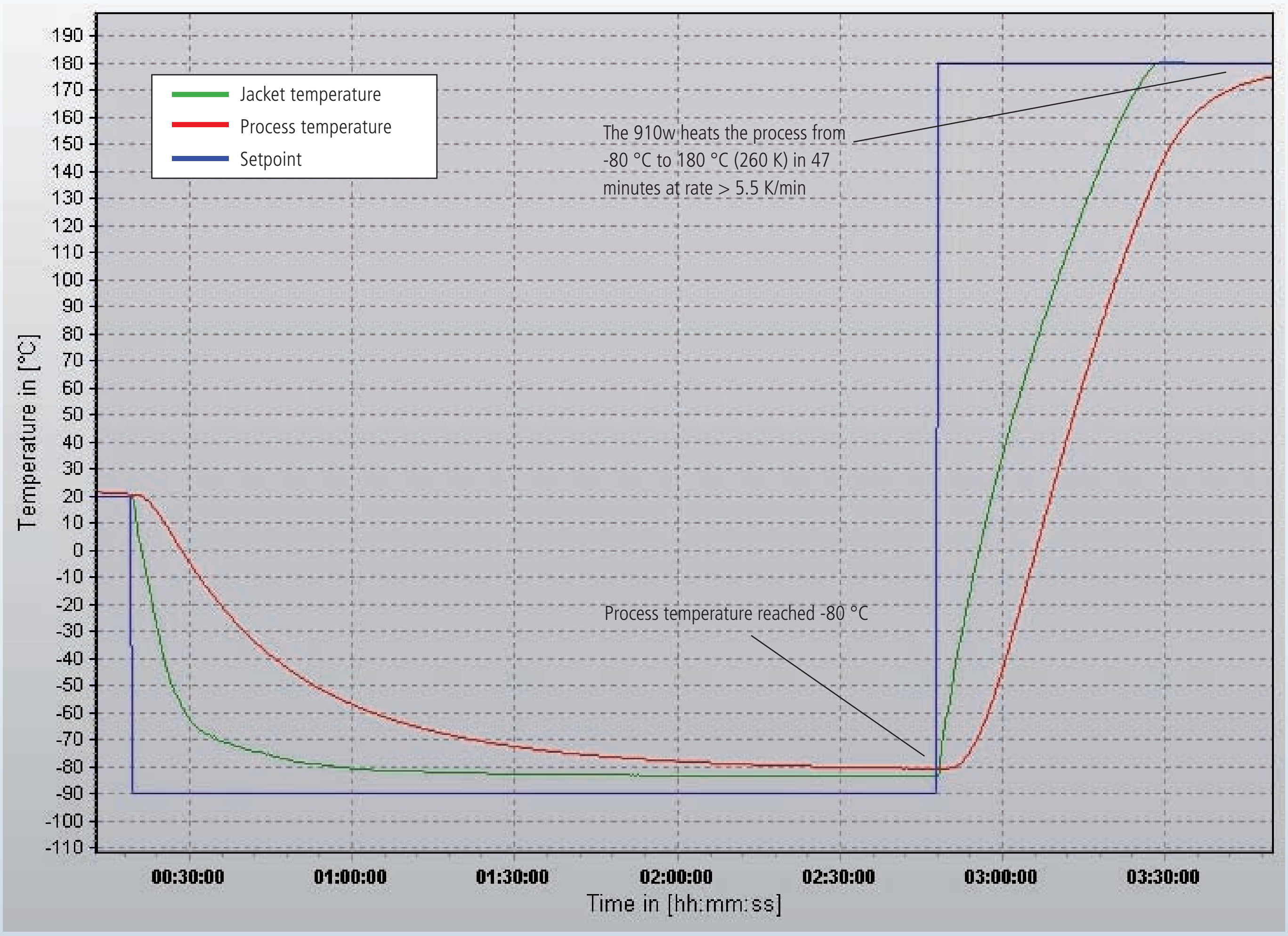
Requirement
The graphic shows the performance of a Unistat® 910w working within its minimum and maximum temperature range when working with DW-Therm as an HTF. The minimum temperature is set to -90 °C but the maximum temperature is limited to 200 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The internal temperature jumps quickly to approximately -63 °C in 11 minutes and regulates the process temperature towards the setpoint. It reaches -80 °C after 2 hours and the ΔT difference is only 3 K.
With a heating power of 6 kW the machine brings the internal temperature to 180 °C very quickly. The temperature difference of 260 K is being ramped at a rate of 5.5 K / min and completed in 47 minutes.

Setup details
Unistat® 910w & Radleys reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C
	4.7 kW @ -40 °C
	3.1 kW @ -60 °C
	0.9 kW @ -80 °C
Heating power:	6.0 kW
Hoses:	2x 1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content	7.5 litre M90.055.03 (#6259)
Stirrer speed	200 rpm
Control	internal



Version: 9/2009

Unistat® 910w

Periodic and Aperiodic on a Radleys 10-litre glass reactor

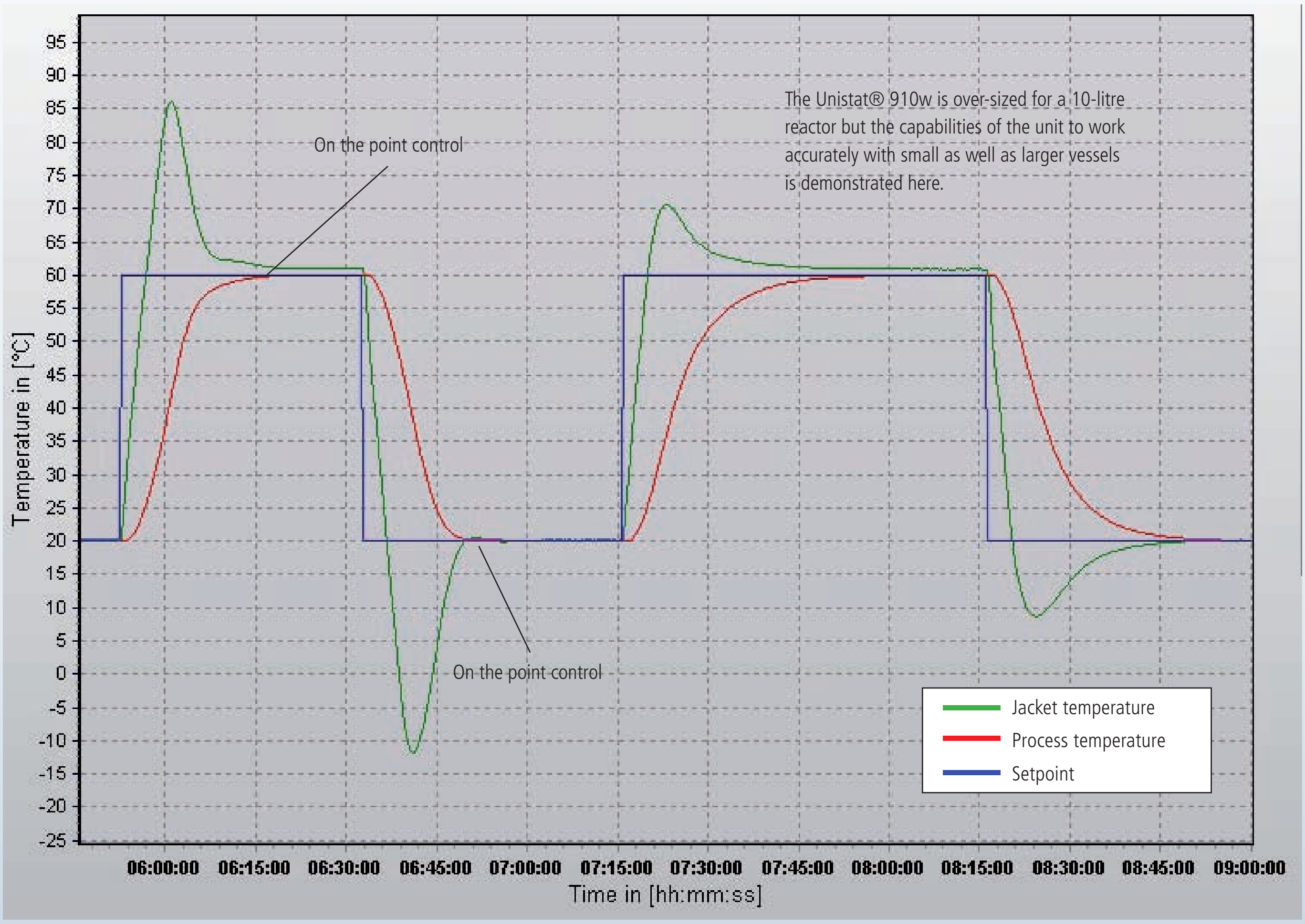
Requirement
Every Unistat® can be set to ramp "Fast with small over shoot" or "No overshoot". This case study looks at the response of a Unistat® 910w working with a Radleys 10-Litre reactor under different "control dynamics".

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The first & second curves (20 °C to 60 °C and back to 20 °C) show the function of "Periodic - fast, small overshoot" control dynamic. The first curve illustrates a heating from 20 °C to 60 °C in a time of 26 minutes. It can be clearly seen that the internal temperature heats to 86 °C, thus the process temperature reaches 60 °C very quickly. The Unistat® 910w cools the 10-litre reactor back to 20 °C in approximately 17 minutes through a ΔT of 40 K.
The third and fourth curves (20 °C to 60 °C to 20 °C) shows the same temperature profile but with "Aperiodic - no overshoot" control. The Unistat® takes slightly longer to heat and cool to avoid any over or undershoot of the set-point.

Setup details
Unistat® 910w & Radleys reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process



Setup details
Unistat® 910w & Radleys reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

Unistat® 910w

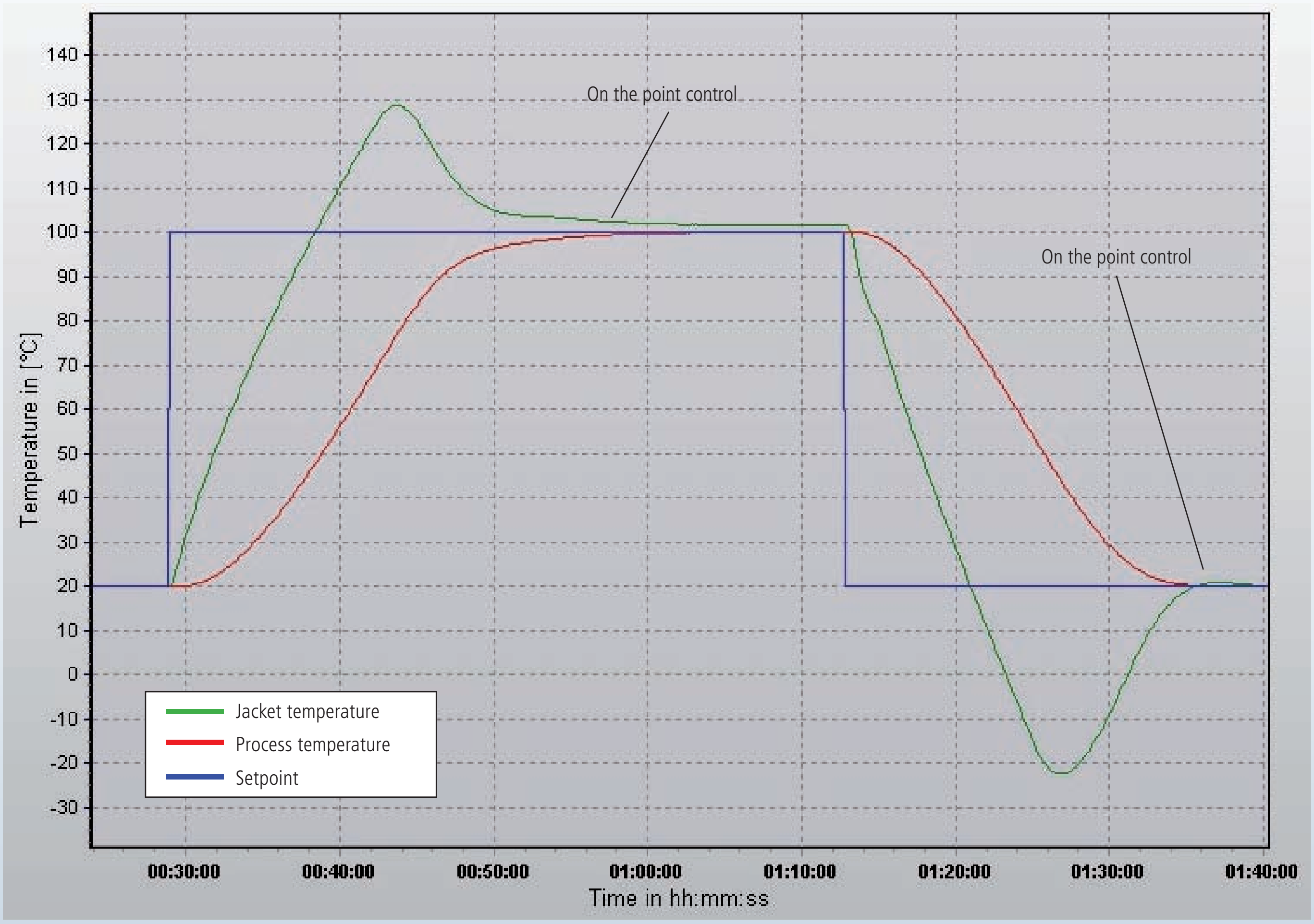
Heating and cooling a Radleys 10-litre glass reactor

Requirement
The graphic shows the temperature profile of a Unistat® 910w working with a Radleys 10-litre glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The Unistat® needs only 36 minutes to heat the reactor up to 100 °C. The process temperature heating rate ramps at > 2.6 K / min. The cooling process temperature back to 20 °C takes 31 minutes to accomplish. This process cooling ramps occurs at a rate of 4.16 K / min.

The Unistat® 910w is over-sized for a 10-litre reactor but the capabilities of the unit to work accurately with small as well as larger vessels is demonstrated here. The superb flexibility of the unit as well as the control capability can clearly be seen here.



Version: 9/2009

Unistat® 910w

Cooling a Radleys 10-litre reactor from 180 °C to 20 °C

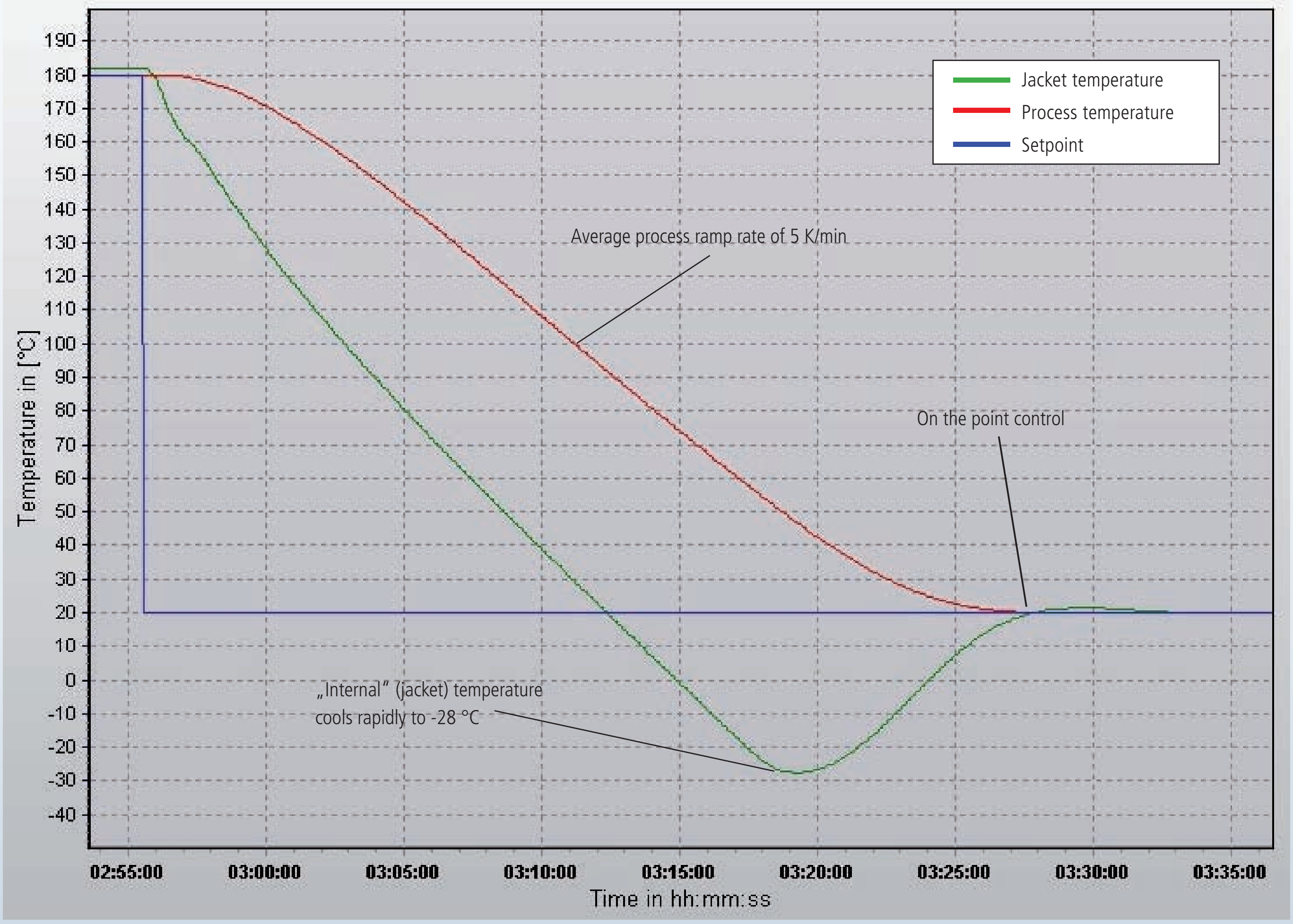
Requirement
This graphic shows the performance of a Unistat® 910w cooling a Radleys 10-litre glass reactor from 180 °C to 20 °C under process control.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The „internal" (jacket) temperature quickly cools to -28 °C pulling the process temperature to the set-point.
The process temperature ramps through 160 K (180 °C to 20 °C) in 32 minutes, a process ramp rate of 5 K / min.

Setup details
Unistat® 910w & Radleys reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process



Setup details
Unistat® 910w & Radleys 10-litre reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C 3.1 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	200 rpm
Control:	process

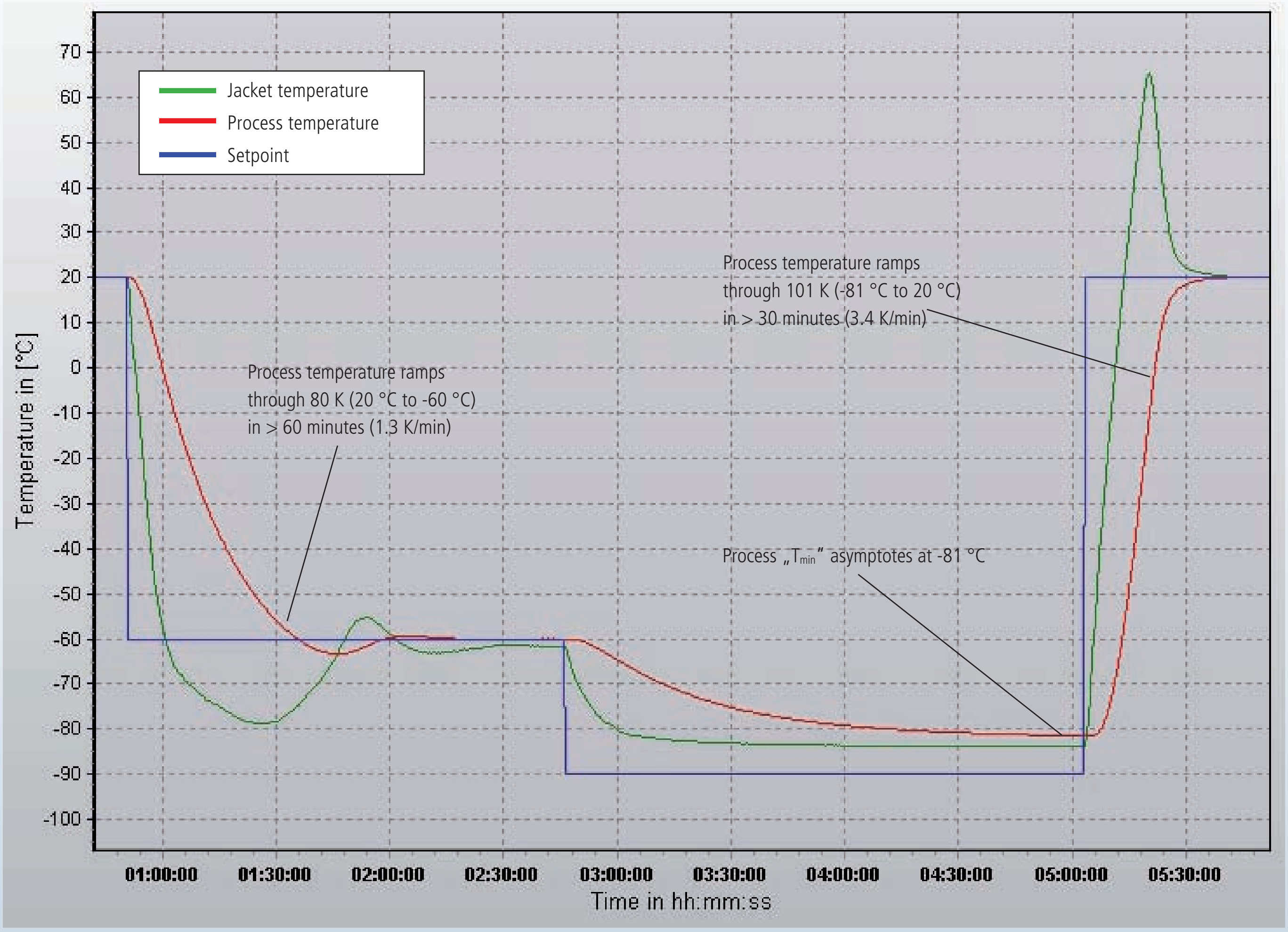
Unistat® 910w

Cooling a Radleys 10-litre reactor to T_{min}

Requirement
The diagram illustrates the performance of a Unistat® 910w undergoing two set-point changes, the second set-point is entered to find out the lowest temperature that the Radleys 10 litre reactor jacket and process can achieve in this set-up (“T_{min}”).

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of “M90.055.03”, a Huber supplied silicon based HTF.

Results
The temperature profile is programmed, controlled and recorded with “Spy Control” software. The Unistat® 910w is connected to a 10-litre glass reactor with a pair of M30x1.5 hoses.
For the first segment the process temperature reach -60 °C in approx. 100 minutes. Then the minimum process temperature achieved was -81 °C with a jacket temperature of -84 °C.



Version: 9/2009

Unistat® 910w

Rapid heating and cooling of a DDPS 25-litre jacketed glass reactor

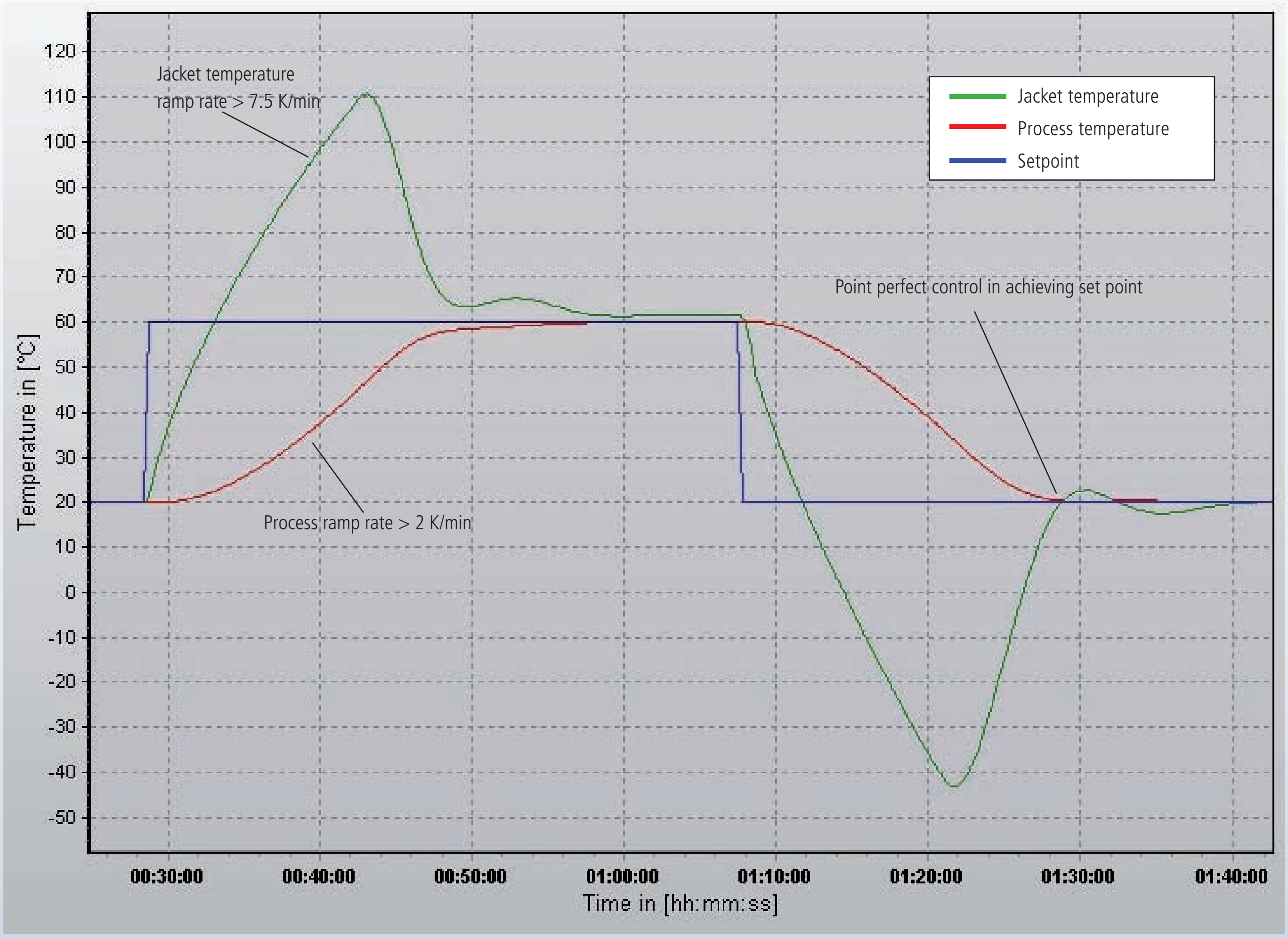
Requirement
This case study demonstrates the heating and cooling performance of a Unistat® 910w connected to a DDPS 25-litre vacuum insulated jacketed glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
To heat the contents (18.75 litre M90.055.03) from 20 °C to 60 °C takes 29 minutes. To cool back to a 20 °C set-point takes approximately 20 minutes.

Setup details
Unistat® 910w & DDPS reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated jacketed glass reactor
Reactor content:	18.75 litre M90.055.03 (#6259)
Stirrer speed:	70 rpm
Control:	process



Setup details
Unistat® 910w & DDPS reactor

Temperature range:	-90...250 °C
Cooling power:	4.7 kW @ -40 °C
	3.1 kW @ -60 °C
	0.9 kW @ -80 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated jacketed glass reactor
Reactor content:	18.75 litre M90.055.03 (#6259)
Stirrer speed:	70 rpm
Control:	process

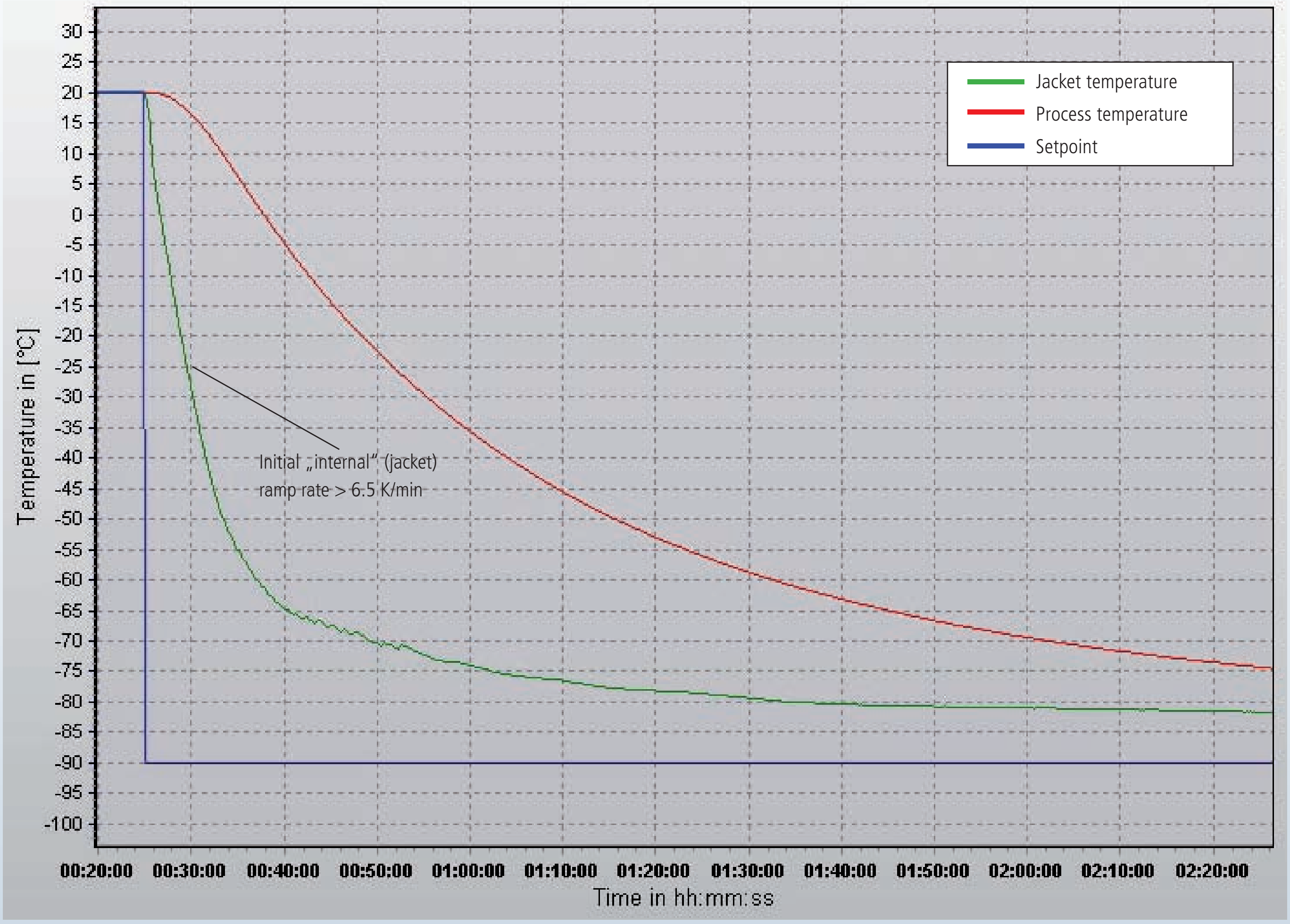
Unistat® 910w

Cooling a DDPS 25-litre jacketed glass reactor to T_{min}

Requirement
The graphic shows the performance of a Unistat® 910w cooling a DDPS 25-litre vacuum insulated jacketed glass reactor to "T_{min}" under process control from 20 to -90 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The „internal" (jacket) temperature cools to -65 °C in just 15 minutes in order to pull the process to the lowest possible temperature.
The reactor is un-insulated and because of high losses the cooling rate asymptotes early with the „internal" (jacket) temperature going no lower than -82 °C during the 2-hour test with a corresponding process "T_{min}" of -75 °C.



Version: 9/2009

Unistat® 910w

Cooling a DDPS 25-litre reactor from 100 °C to 20 °C

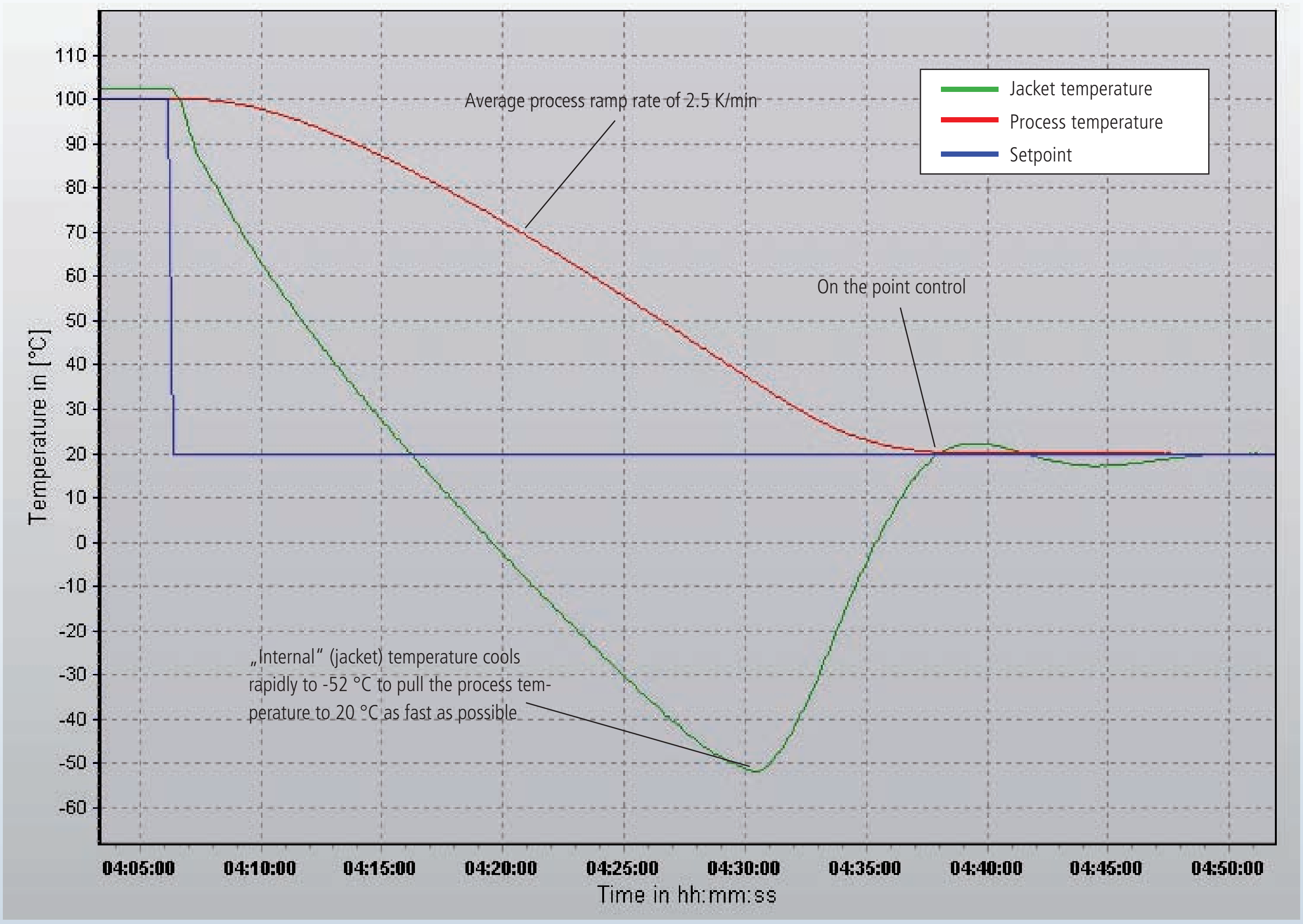
Requirement
The graphic shows the performance of a Unistat® 910w working to cool a DDPS 25-litre vacuum insulated reactor from 100 °C to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The internal temperature cools to approximately -52 °C cooling to create a wide ΔT resulting in the the process temperature ramping quickly through 80 K to reach the set-point temperature in 40 minutes.

Setup details
Unistat® 910w & DDPS reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated jacketed glass reactor
Reactor content:	18.75 litre M90.055.03 (#6259)
Stirrer speed:	70 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 910w & DDPS reactor

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C 3.1 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	25 litre vacuum insulated jacketed glass reactor
Reactor content:	18.75 litre M90.055.03 (#6259)
Stirrer speed:	70 rpm
Control:	process

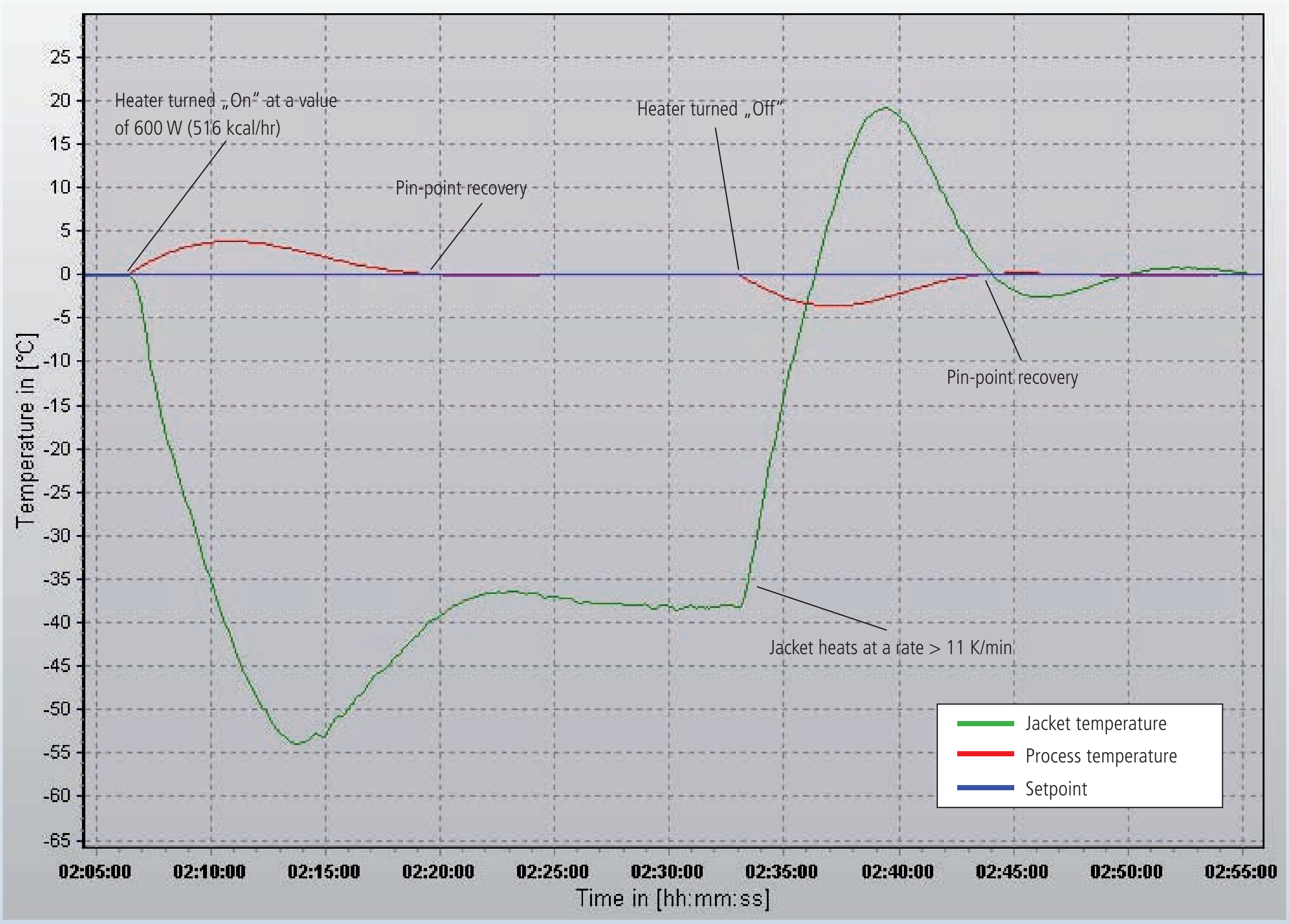
Unistat® 910w

Controlling an exothermic reaction of 600 W (516 kcal / hr) in a DDPS 25-litre jacketed glass reactor

Requirement
The test is conducted to investigate the performance of Unistat® 910w controlling a simulated 600 W (516 kcal/hr) exothermic reaction in a DDPS 25-litre vacuum insulated glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 18.75 litre of "M90.055.03", a Huber supplied silicon based HTF. The simulated reactions are carried out using a controlled electric immersion heater.

Results
When an increase in temperature caused by the simulated exothermic reaction is sensed the jacket temperature reacts very quickly to remove the heat. A cooling rate of approx. 7.7 K / min equals the temperature rise of approx. 3.7 K within 13 minutes and the set-point is kept exactly on the set-point.



Unistat® 910w

Alternating between 20 °C and -60 °C on a Büchi 10-litre reactor

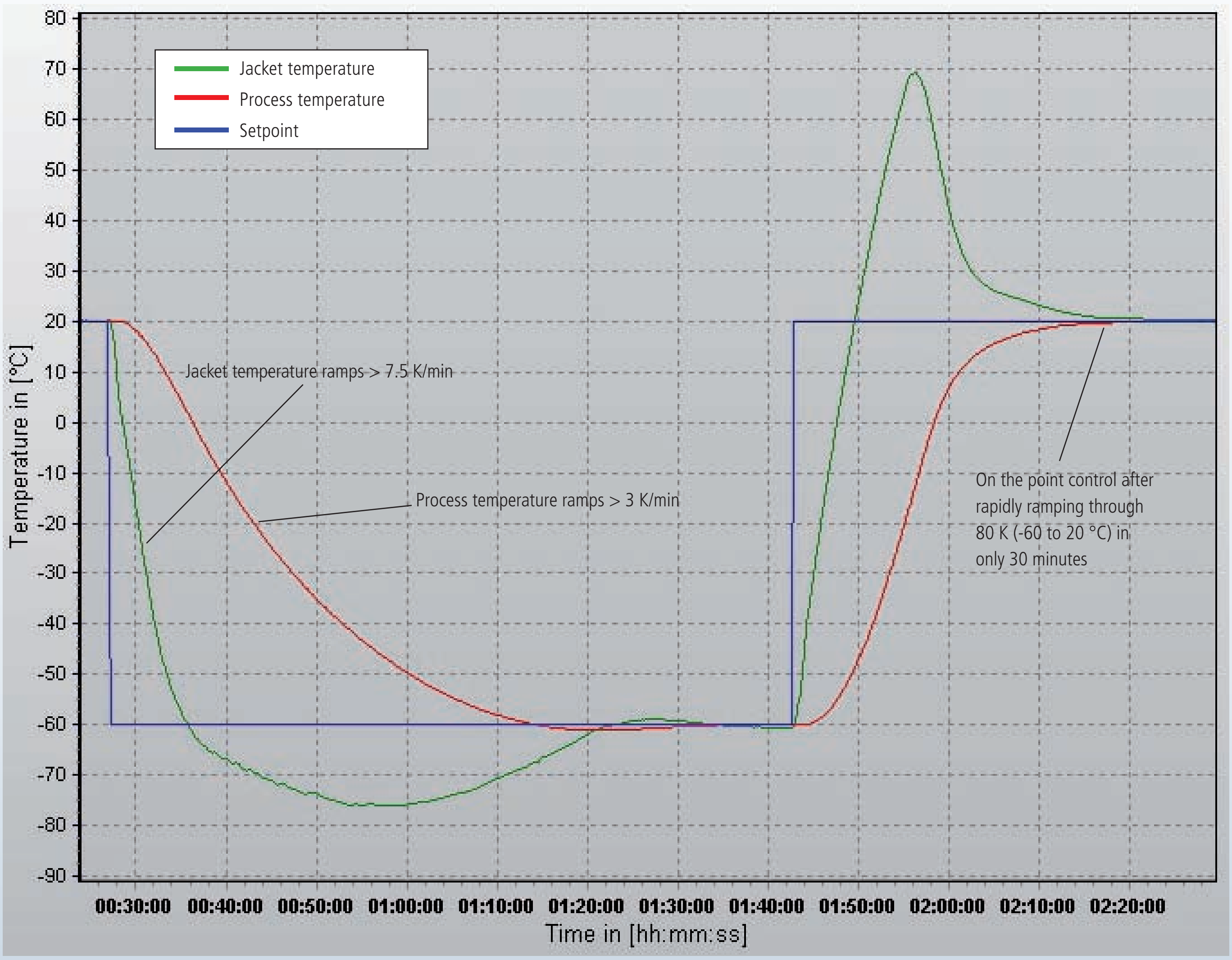
Requirement
The graphic shows the cooling and heating performance of a Unistat® 910w cooling and heating a Büchi 10-litre reactor between 20 °C and -60 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 7.5 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The „internal" (jacket) temperature cools to -65 °C within 10 minutes and finally to -77 °C to pull the process temperature as quickly as possible to -60 °C. This represents a cooling rate of 7.8 K / min and the cooling process is completed in 65 minutes.
Meanwhile the heating process occurs at a rate of 10.5 K / min at the internal temperature. It jumps to approximately 70 °C and pulls the process temperature to 20 °C in 30 minutes.

Setup details
Unistat® 910w & Büchi «miniPilot» 10 reactor (büchiglasuster)

Temperature range:	-90...250 °C
Cooling power:	5.2 kW @ 250…-20 °C 4.7 kW @ -40 °C 3.1 kW @ -60 °C
Heating power:	6.0 kW
Hoses:	2x1.5 m; M30x1.5 (#6386)
HTF:	DW-Therm (#6479)
Reactor:	10 litre jacketed glass reactor
Reactor content:	7.5 litre M90.055.03 (#6259)
Stirrer speed:	400 rpm
Control:	process



Setup details
Unistat® 910w & Diehm 100-litre reactor

Temperature range:	-90…250 °C
Cooling power:	5.2 kW from 250 °C to -20 °C 4.7 kW @ -40 °C 3.1 kW @ -60 °C 0.9 kW @ -80 °C
Heating power:	6.0 kW
Hoses:	M38x1.5; 1x 2m #6657 ; 1x1m # 6655, VPC Bypass installed
HTF:	M90.055.03 (#6259)
Reactor:	100-litre Diehm un-insulated jacketed glass reactor
Reactor content:	75 litre M90.055.03
Stirrer speed:	410 rpm
Control:	process

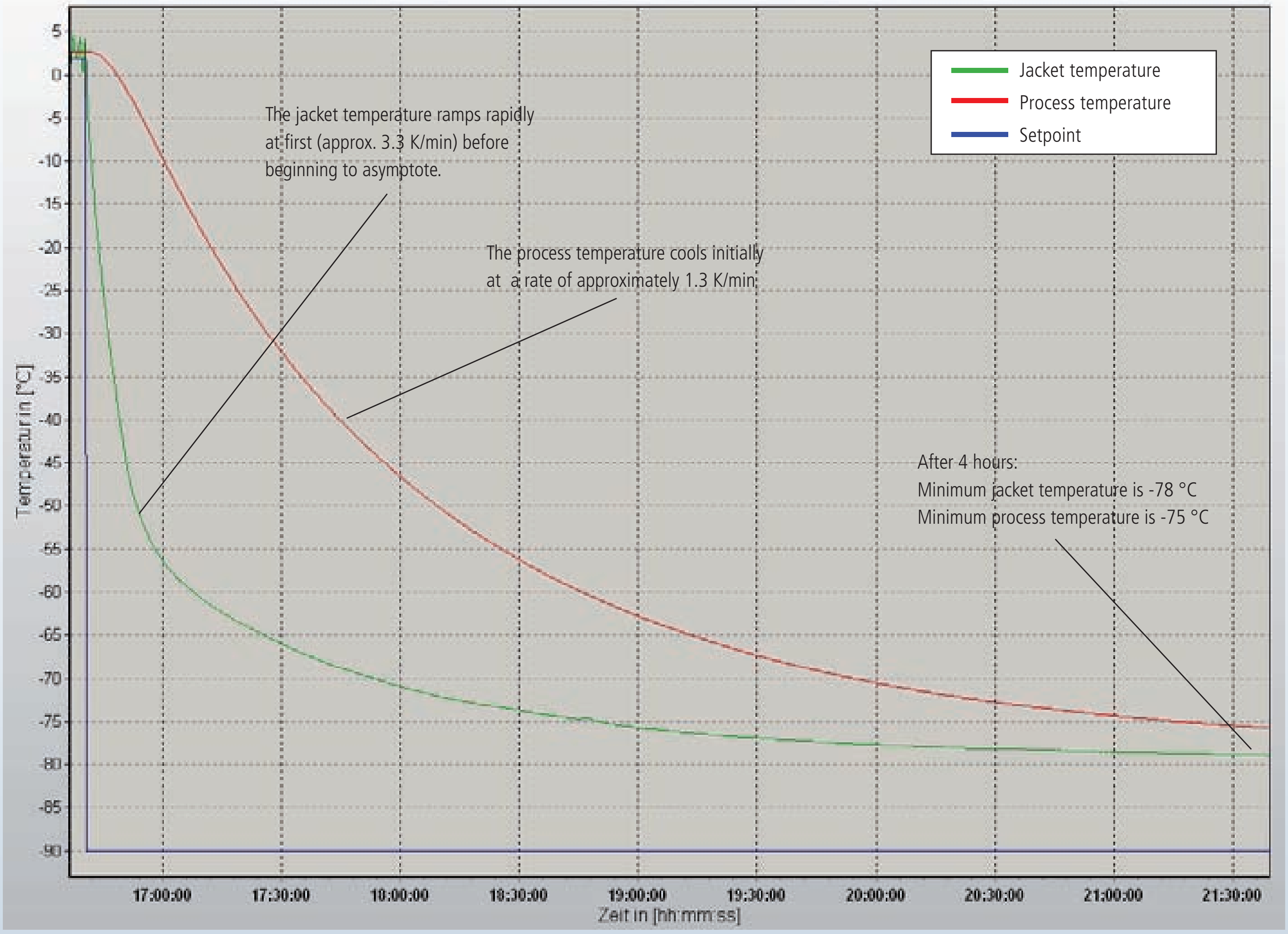
Unistat® 910w

Cooling a Diehm 100-litre jacketed glass reactor to T_{min}

Requirement
This case study looks at the minimum process temperature that a Diehm 100-litre reactor can reach when connected to a Unistat® 910w.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
A 100-litre reactor represents a large thermal load for the Unistat® 910w which is designed to operate on reactors of up to 50-litre however, over time the Unistat® 910w can still bring the process temperature to -75 °C.



Version: 9/2009

Unistat® 910w

Cooling a Diehm 100-litre jacketed glass reactor to -30 °C from 120 °C

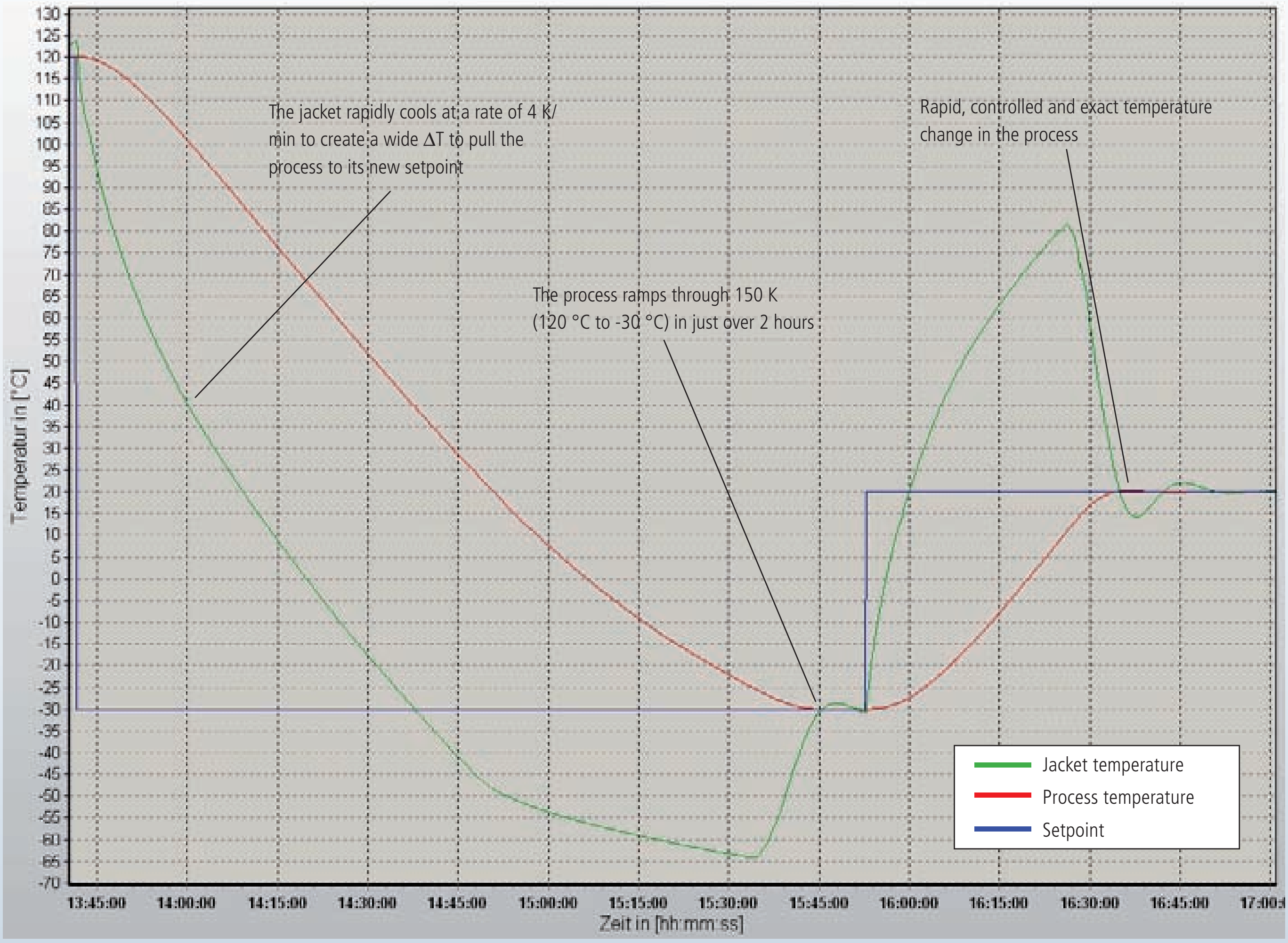
Setup details
Unistat® 910w & Diehm 100-litre reactor

Temperature range:	-90…250 °C
Cooling power:	5.2kW from 250 °C to -20 °C 4.7kW @ -40 °C 3.1kW @ -60 °C 0.9kW @ -80 °C
Heating power:	6.0 kW
Hoses:	M38x1.5; 1x 2m #6657; 1x1m # 6655, VPC Bypass installed
HTF:	M90.055.03 (#6259)
Reactor:	100-litre Diehm un-insulated jacketed glass reactor
Reactor content:	75 litre M90.055.03
Stirrer speed:	410 rpm
Control:	process

Requirement
This case study examines the performance of a Unistat® 910w cooling a Diehm 100-litre jacketed glass reactor from 120 °C to -30 °C then back to 20 °C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
Though the Unistat® 910w is designed for (efficient) use on reactors up to a maximum of 50-litre, it can be seen how well the Unistat® 910w performs on a reactor twice that size. The control is exact in both heating and cooling as can be seen from the graphic below.



Version: 9/2009

Setup details
Unistat® 910w & Diehm 100-litre reactor

Temperature range:	-90…250 °C
Cooling power:	5.2 kW from 250 °C to -20 °C 4.7 kW @ -40 °C 3.1 kW @ -60 °C 0.9 kW @ -80 °C
Heating power:	6.0 kW
Hoses:	M38x1.5; 1x 2m #6657; 1x1m # 6655, VPC Bypass installed
HTF:	M90.055.03 (#6259)
Reactor:	100-litre Diehm un-insulated jacketed glass reactor
Reactor content:	75 litre M90.055.03
Stirrer speed:	410 rpm
Control:	process

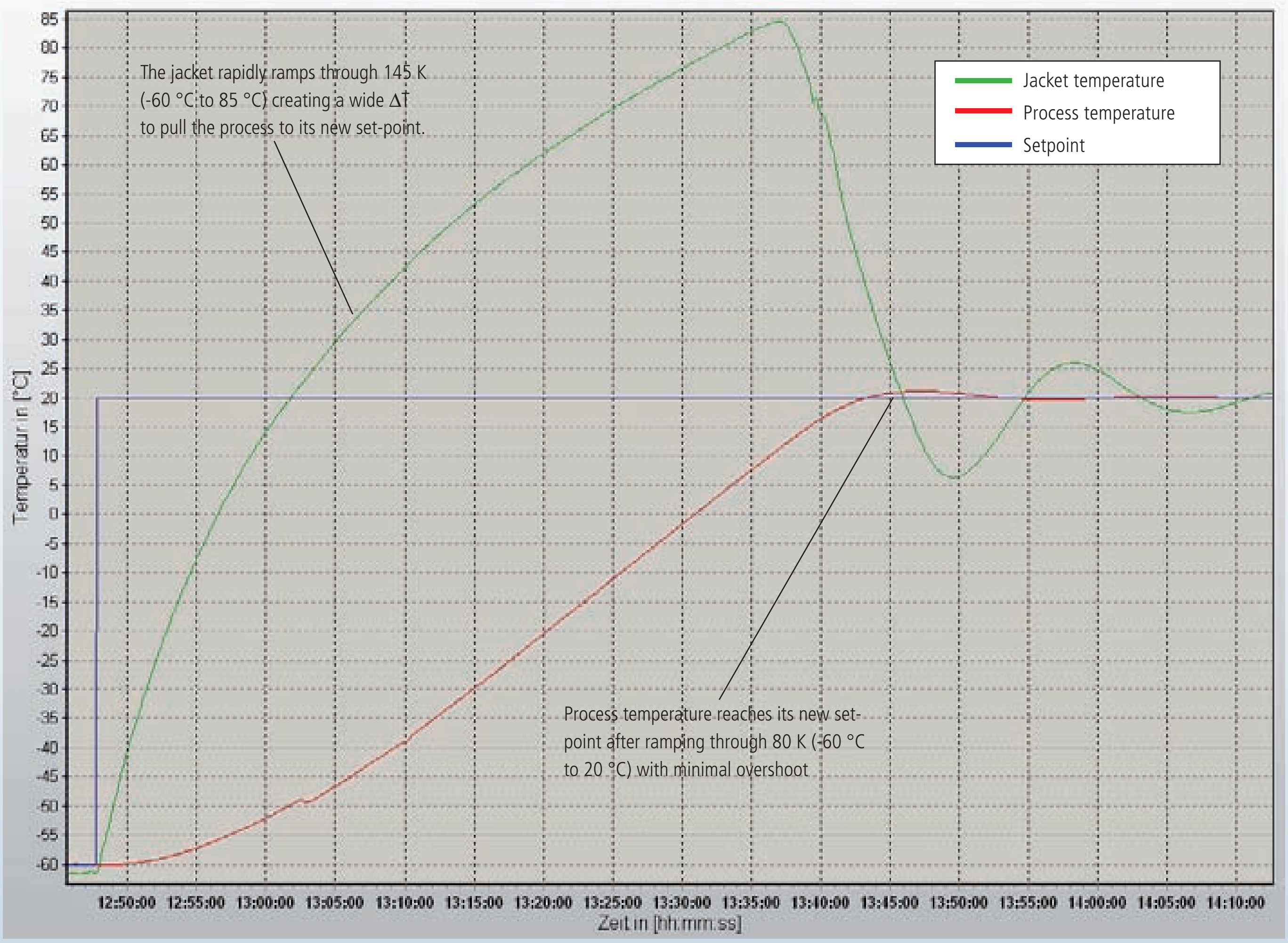
Unistat® 910w

Heating a Diehm 100-litre jacketed glass reactor from -60 °C to 20 °C

Requirement
This case study looks at the speed of response when the process temperature set-point is changed from -60 °C to 20 °C in a Diehm 100-litre jacketed glass reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
It can be seen that the jacket temperature ramps rapidly from -60 °C to 85 °C in around 50 minutes (average ramp rate of around 3 K / min) and as the process approaches its set-point, ramping back to guide the process exactly to its new set-point within 55 minutes (average ramp rate of 1.5 K / min) with a negligible over-shoot.



Unistat® 910w

Heating a Diehm 100-litre jacketed glass reactor from -80 °C to 20 °C

Requirement

This case study shows the effectiveness of a Unistat® 910w in heating a Diehm 100-litre jacketed glass reactor from -80 °C to 20 °C.

Method

The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

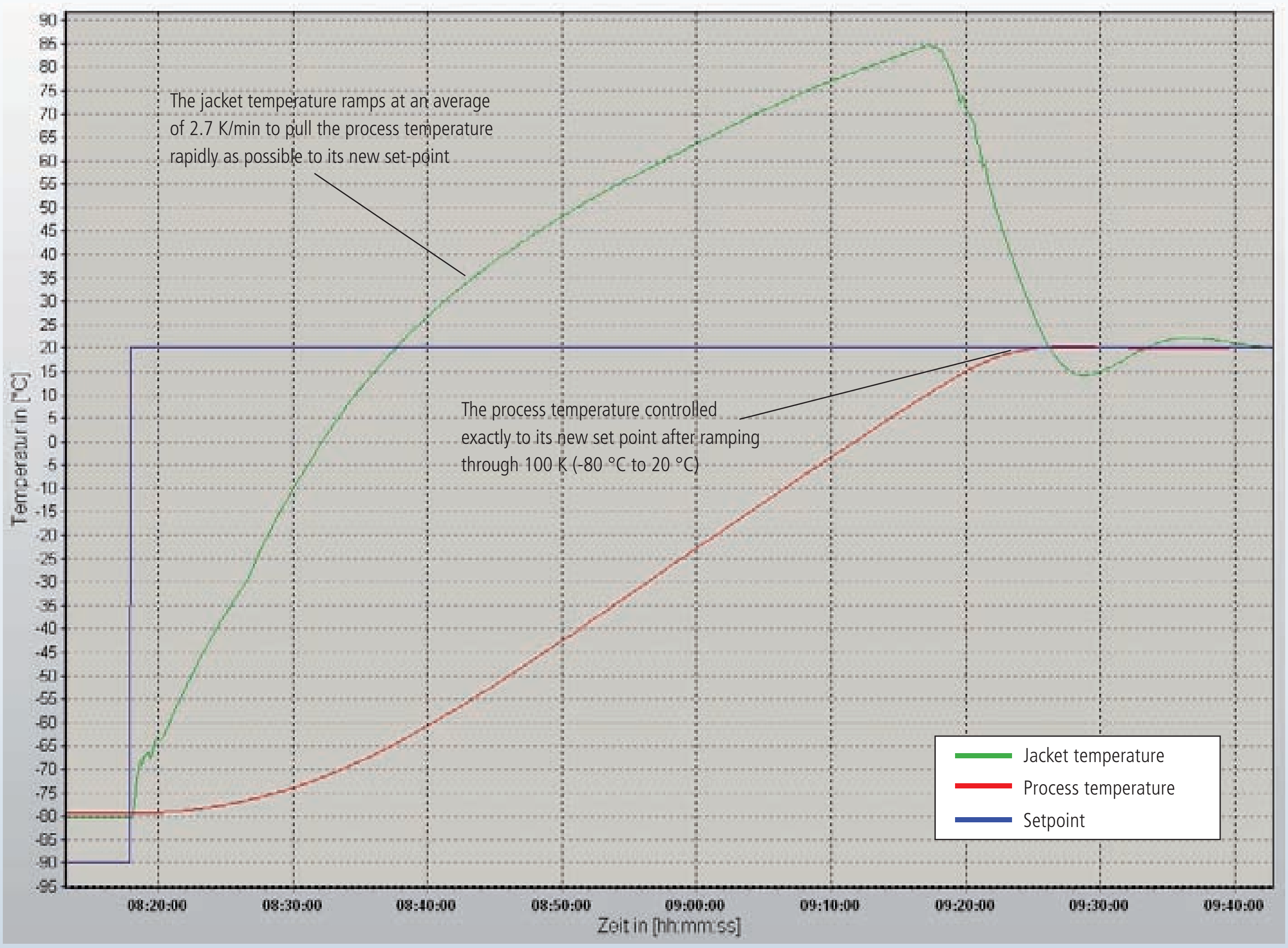
Results

It can be seen that the jacket temperature ramps rapidly through 165 K (-80 to 85 °C) within 1 hour then ramping quickly down as the process approaches its target to guide the process temperature to its new set-point.
Though oversized for a Unistat® 910w (designed for efficient operation on reactors to a maximum of 50-litre), the speed and accuracy of the control is evident in the graphic below.

Setup details

Unistat® 910w & Diehm 100-litre reactor

Temperature range:	-90…250 °C
Cooling power:	5.2 kW from 250 °C to -20 °C 4.7 kW @ -40 °C 3.1 kW @ -60 °C 0.9 kW @ -80 °C
Heating power:	6.0 kW
Hoses:	M38x1.5; 1x 2m #6657; 1x1m # 6655, VPC Bypass installed
HTF:	M90.055.03 (#6259)
Reactor:	100-litre Diehm un-insulated jacketed glass reactor
Reactor content:	75 litre M90.055.03
Stirrer speed:	410 rpm
Control:	process



Version: 9/2009

Setup details

Temperature range:	–90...200 °C
Cooling power:	16 kW @ 200…–20 °C 15 kW @ –40 °C 13,5 kW @ –60 °C
Heating power:	24 kW
Hoses:	M38x1,5; 2*2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre insulated jacketed glass reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process

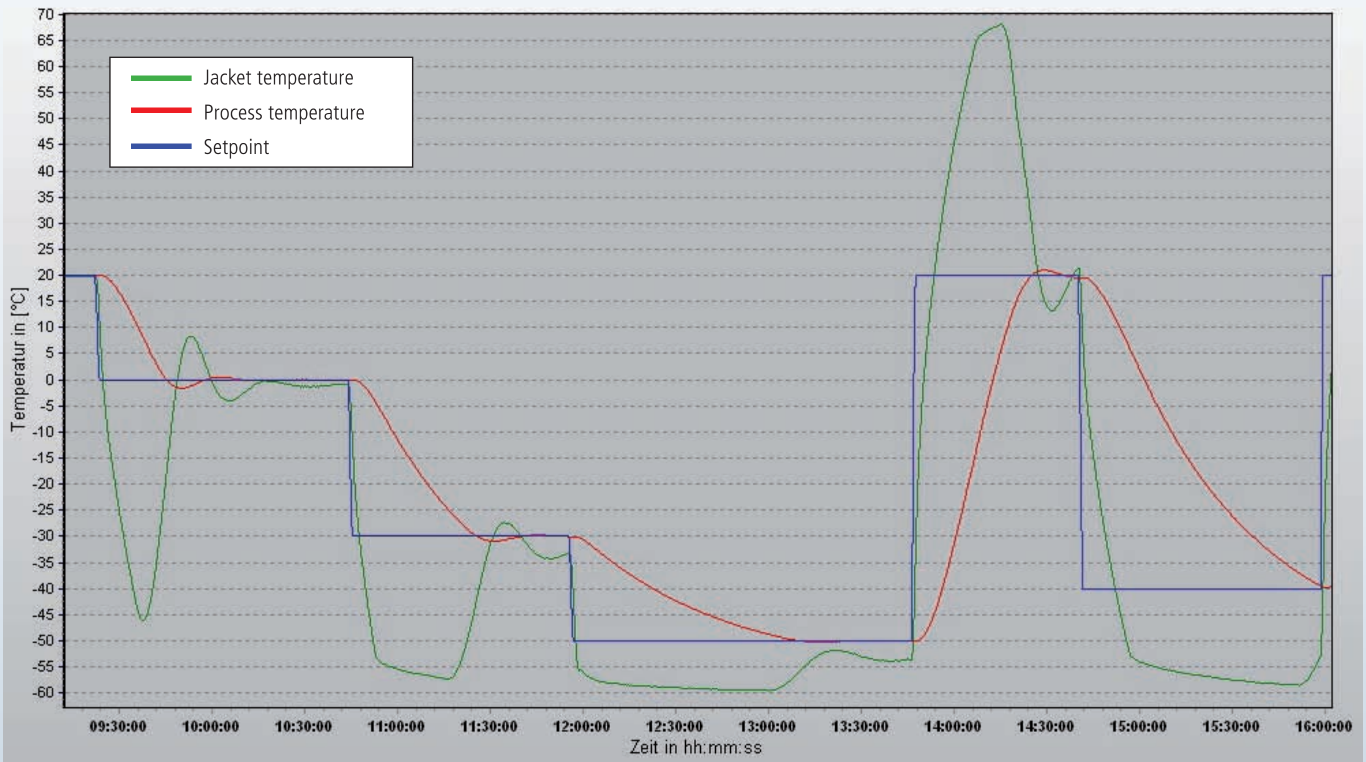
Unistat® 925w

Controlled rate cooling of a Büchi «chem-reactor» CR252, a 250-litre GLSS reactor

Requirement
When cooling a GLSS reactor it is vital to do so in a manner that does not damage the glass lining. This case study examines the capability of a Unistat® 925w to cool the process temperature in pre-programmed steps to -50°C from 20°C.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 200 litre of Ethanol.
Unistat® was limited to T_{min} -60 °C due to GLSS-reactor limitation.

Results
The minimum jacket temperature of the Büchi reactor was limited to -60 °C as was the ramp rate to avoid damaging the glass lining.
It can be seen that each step reaches its set-point effortlessly and is maintained precisely to allow the glass lining and steel body of the reactor to harmonize before the next cool-down step is made.



Version: 9/2009

Unistat® 925w

??????????????????????????????????????
???????????????????????

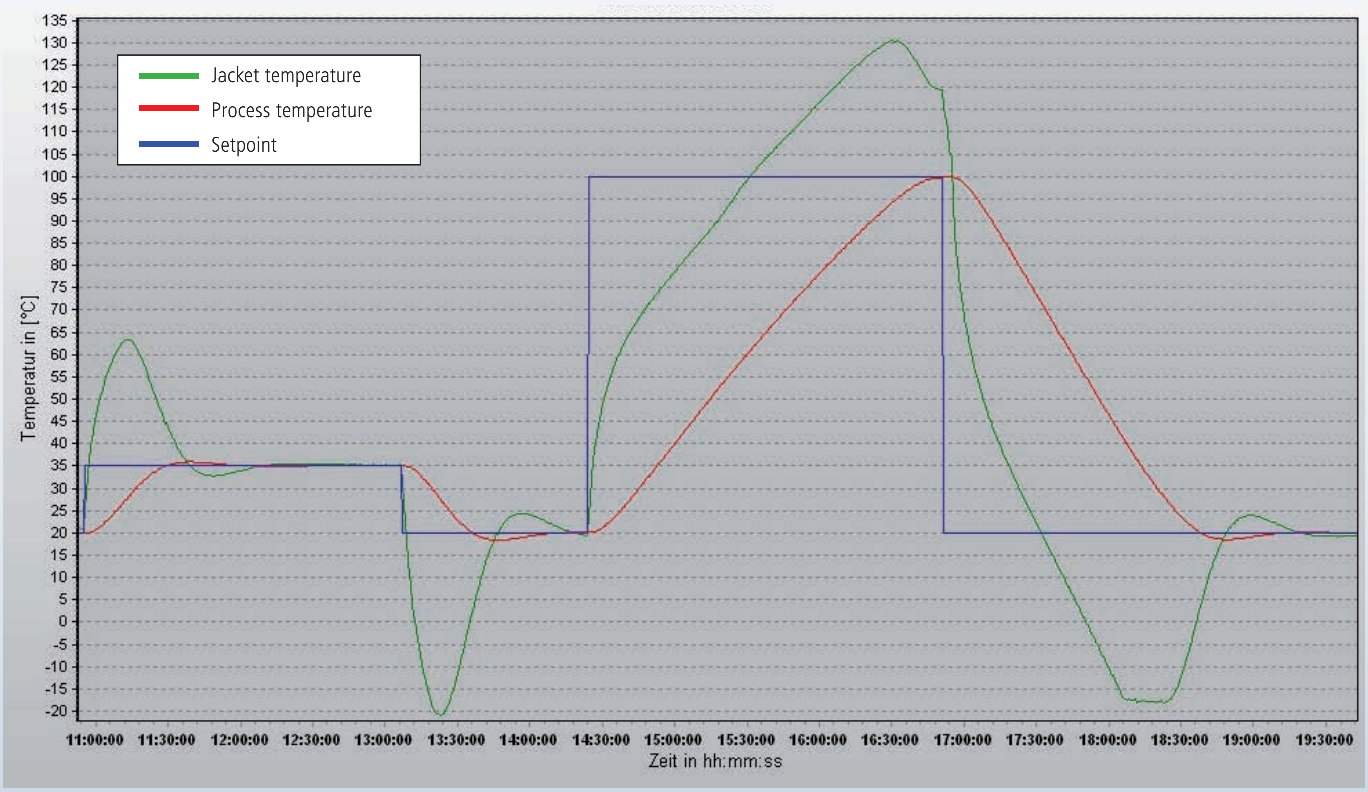
Requirement
This case study looks at the capability of the Unistat® 925w at controlling a Büchi CR252 filled with 200-litre of water.

Method
The Unistat® and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 200 litre of water.
Firstly using TAC´s singleshot identification from 20 °C to 35 °C. Back at 20 °C the test run up to 100 °C waas started. While reaching 100 °C the setpoint was changed immediately due to the physical of water property.

Results
The minimum jacket temperature of the Büchi reactor was limited to -60 °C as was the ramp rate to avoid damaging the glass lining.
Water represents a very "heavy" thermal load with a specific heat capacity (cp) of 4.18 KJ / Kg K. Despite this it can be seen that the Unistat® 925w is able to heat and cool this relatively large mass from 20°C to 100°C and back to 20°C under tight and predictable control.

Setup details

Temperature range:	–90...200 °C
Cooling power:	16 kW @ 200…–20 °C 15 kW @ –40 °C 13,5 kW @ –60 °C
Heating power:	24 kW
Hoses:	M38x1,5; 2*2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre insulated jacketed GLSS reactor
Reactor content:	200-litre water
Reactor stirrer speed:	90 rpm
Control:	process



Setup details

Temperature range:	–90...200 °C
Cooling power:	16 kW @ 200…–20 °C 15 kW @ –40 °C 13,5 kW @ –60 °C
Heating power:	24 kW
Hoses:	M38x1,5; 2*2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre insulated jacketed reactor
Reactor content:	200-litre water
Reactor stirrer speed:	90 rpm
Control:	process

Unistat® 925w

Controlling a Büchi CR252 GLSS reactor filled with water

Requirement

This case study examines the tightness and speed of control when a Unistat® 925w is used with a Büchi CR252 reactor filled with 200-litre of water.

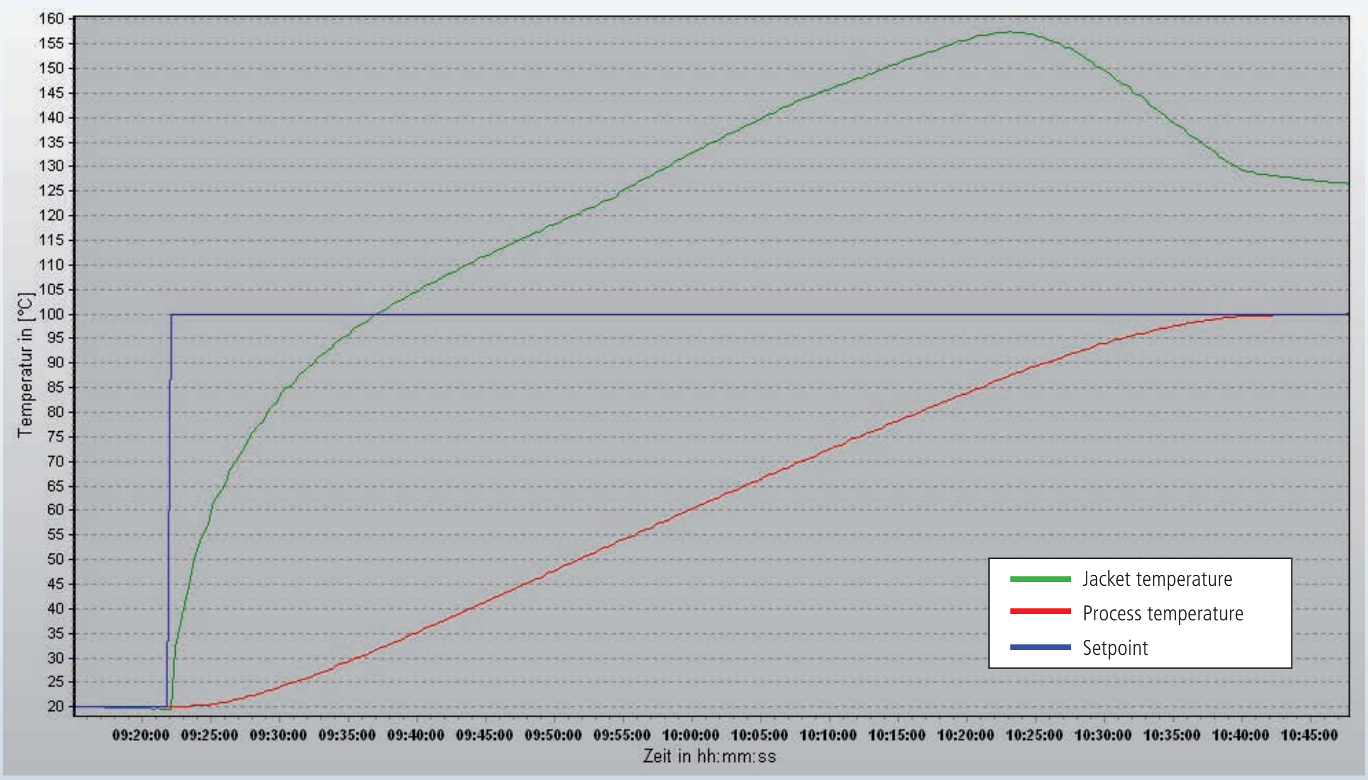
Method

The Unistat® and reactor are connected using two 2-metre insulated metal hoses.
The reactor is filled with 200 litre of water.

Results

The minimum jacket temperature of the Büchi reactor was limited to -60 °C as was the ramp rate to avoid damaging the glass lining.
It can be seen that the heat up curve is linear for almost the entire process before reaching and stabilising exactly at the set-point of 100 °C.

Heat up curve with 24 kW heating power



Version: 9/2009

Unistat® 925w

Controlling a Büchi CR252 GLSS reactor filled with water

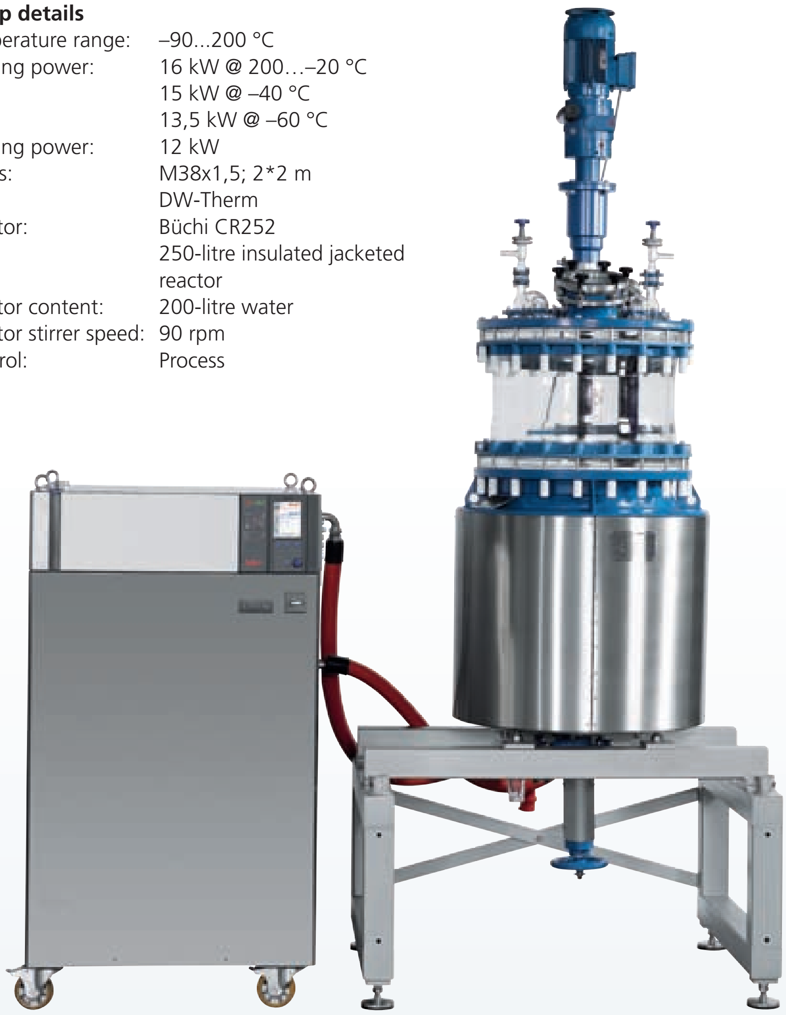
Requirement
This case study examines the tightness and speed of control when a Unistat® 925w is used with a Büchi CR252 reactor filled with 200-litre of water.

Method
The Unistat® and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 200 litre of water.

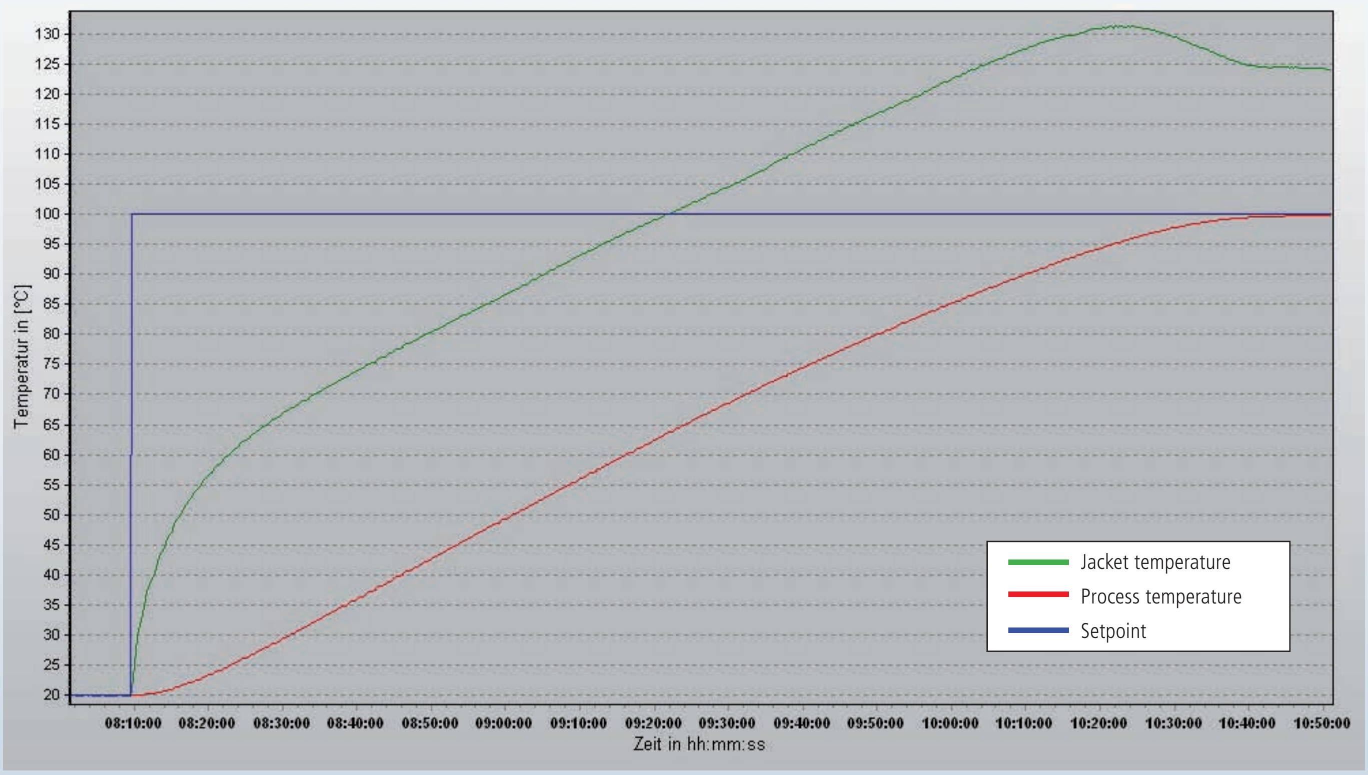
Results
It can be seen that the heat up curve is linear for almost the entire process before reaching and stabilising exactly at the set-point of 100 °C.

Setup details

Temperature range:	–90...200 °C
Cooling power:	16 kW @ 200…–20 °C 15 kW @ –40 °C 13,5 kW @ –60 °C
Heating power:	12 kW
Hoses:	M38x1,5; 2*2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre insulated jacketed reactor
Reactor content:	200-litre water
Reactor stirrer speed:	90 rpm
Control:	Process



Heat up curve with 12 kW heating power



Unistat® 925w

Predictable and repeatable control of a Büchi CR252 GLSS reactor

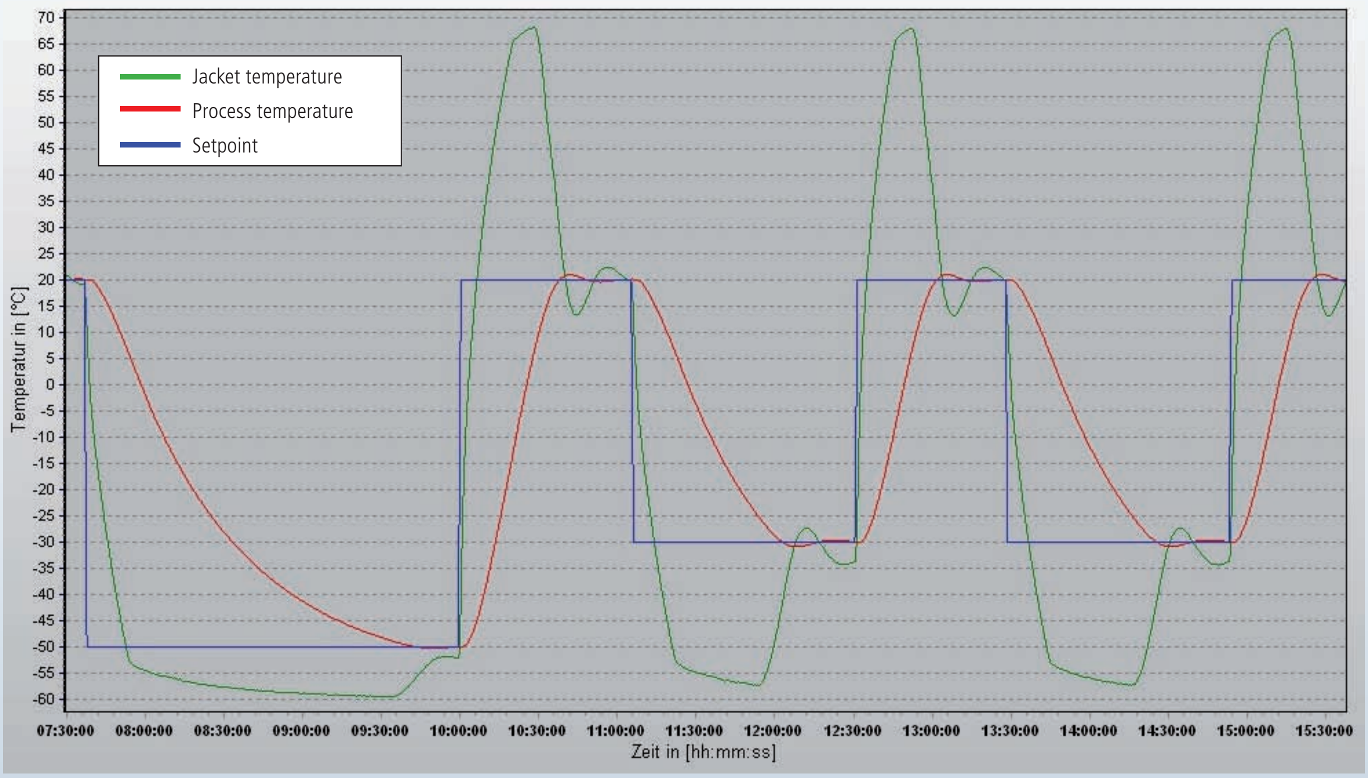
Setup details

Temperature range:	–90...200 °C
Cooling power:	16 kW @ 200…–20 °C 15 kW @ –40 °C 13,5 kW @ –60 °C
Heating power:	24 kW
Hoses:	M38x1,5; 2*2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre insulated jacketed reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process

Requirement
This case study examines the performance of a Unistat® 925w when connected to a Büchi 250-litre insulated jacketed GLSS reactor.

Method
The Unistat® and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 200 litre of Ethanol.

Results
The minimum jacket temperature of the Büchi reactor was limited to -60 °C as was the ramp rate to avoid damaging the glass lining. It can be seen that the Unistat® 925w was still well within its maximum performance capabilities at this temperature.
The first curve shows the process temperature being lowered to -50 °C from 20 °C (70 K) which the 925w achieved in approximately 2-hours. The process temperature set-point is maintained with a ΔT of only (approximately) 2 K.
The next curve demonstrates the heat-up capability of the Unistat® 925w by returning the process temperature to 20 °C from -50 °C in approximately 40-minutes.
The following curves show the repeatability and predictability of the performance of the Unistat® 925w by ramping the process temperature between 20 °C and -30 °C, each curve being exactly the same.



Version: 9/2009

Unistat® 925w

Cooling a Büchi 250 litre jacheted GLSS reactor to T_{min}

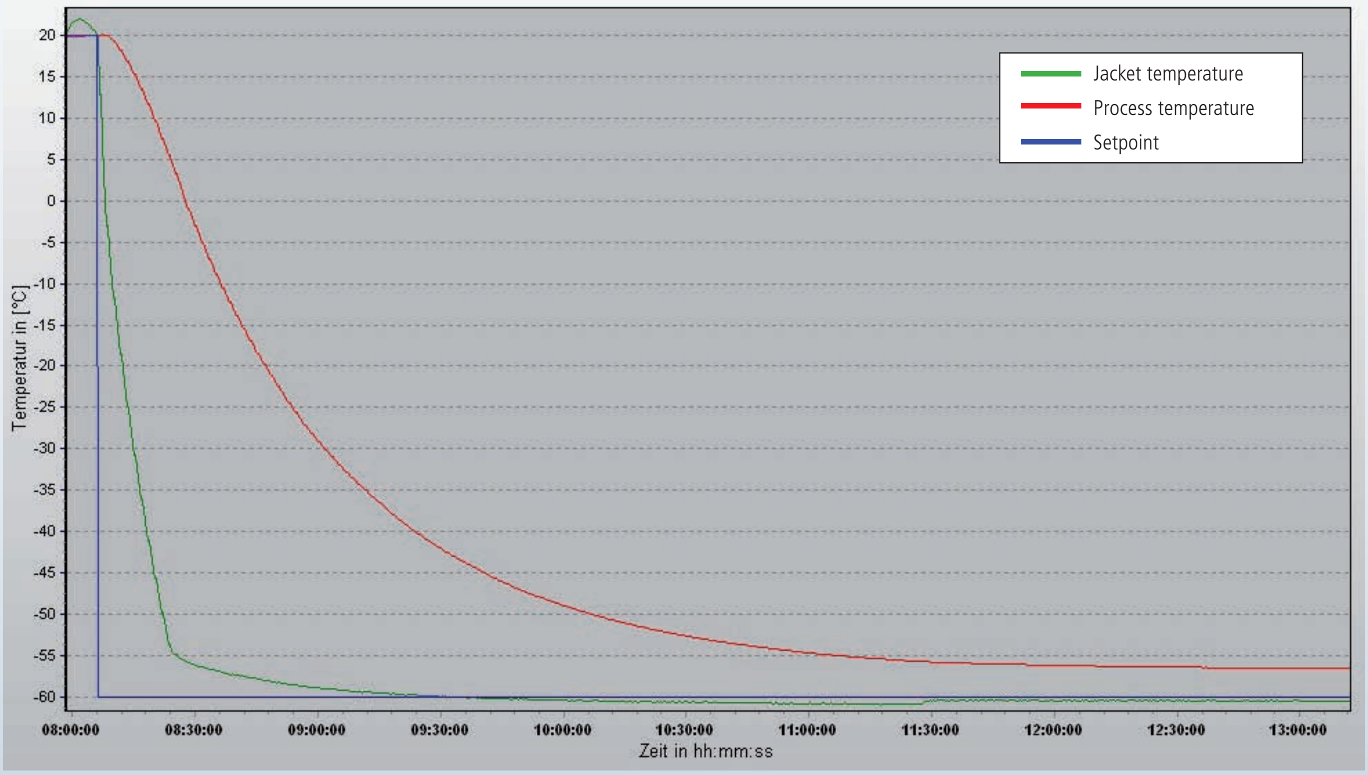
Requirement
This case study determines the minimum temperature achievable when a Unistat® 925w is connected to a Büchi CR252 GLSS reactor.

Method
The Unistat® and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 200 litre of Ethanol.

Results
The minimum jacket temperature of the Büchi reactor was limited to -60 °C as was the ramp rate to avoid damaging the glass lining.
The Jacket cools rapidly to asymptote at -60 °C resulting in a minimum process temperature of -57 °C.

Setup details

Temperature range:	–90...200 °C
Cooling power:	16 kW @ 200…–20 °C 15 kW @ –40 °C 13,5 kW @ –60 °C
Heating power:	24 kW
Hoses:	M38x1,5; 2*2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre glass-lined (enameled) steel reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process



Unistat® 925w

Controlling a Büchi «chemReactor» CR252 GLSS reactor between -40 °C and 20 °C

Setup details

Temperature range:	-90...200 °C
Cooling power:	16 kW @ 200…-20 °C 15 kW @ -40 °C 13,5 kW @ -60 °C
Heating power:	24 kW
Hoses:	M38x1,5; 2*2 m
HTF:	DW-Therm
Reactor:	Büchi CR252 250-litre glass-lined (enameled) steel reactor
Reactor content:	200-litre Ethanol
Reactor stirrer speed:	90 rpm
Control:	process

Requirement

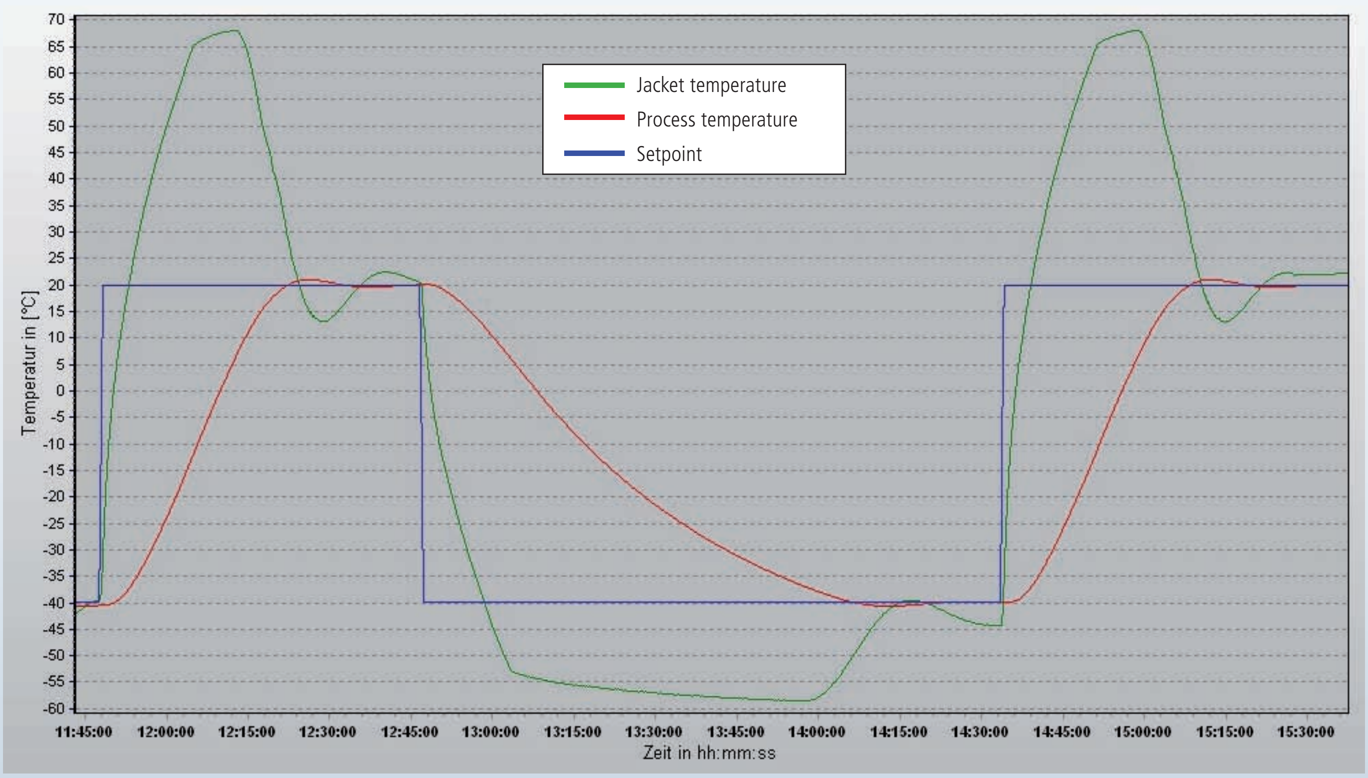
This case study looks at the ease with which a Unistat® 925w controls the process temperature of 200-litre of Ethanol within a Büchi Glas CR252 GLSS reactor.

Method

The Unistat® and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 200 litre of Ethanol.

Results

The minimum jacket temperature of the Büchi reactor was limited to -60 °C as was the ramp rate to avoid damaging the glass lining.
It can be sen that the jacket can be rapidly ramped to pull the process temperature from 20 °C to -40 °C, maintained at exactly -40 °C before being returned to 20 °C.



Version: 9/2009

Unistat® 930w

Controlling a Büchi CR101, a 100-litre GLSS reactor from 20 °C to -40 °C

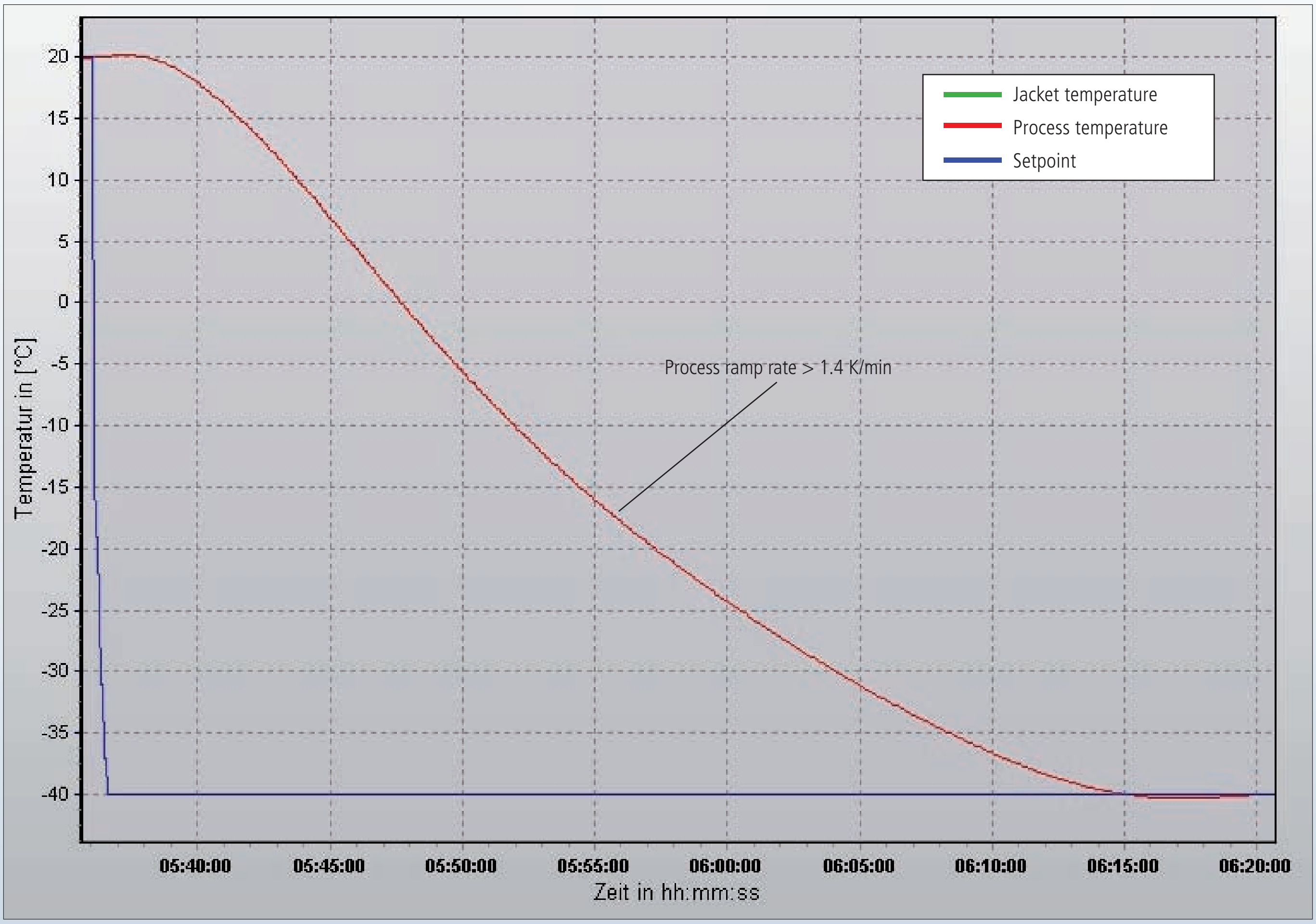
Requirement
The graphic demonstrates the capability of a Unistat® 930w to cool a 100-litre reactor from 20 °C to -40 °C.

Method
The Unistat® and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The process temperature reaches its target of -40 °C within 43 minutes representing a ramp-rate > 1.4 K / min.

Setup details
Unistat® 930w & 100-litre Büchi «chemReactor» CR101 (büchiglasuster)

Temperature range:	-90...200 °C
Cooling power:	20 kW @ 0…-40 °C 15 kW @ -60 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre glass-lined (enameled) steel reactor
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process



Version: 9/2009

Setup details
Unistat® 930w & 100-litre Büchi «chemReactor» CR101 (büchiglasuster)

Temperature range:	-90...200 °C
Cooling power:	20 kW @ 0…-40 °C 15 kW @ -60 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre glass-lined (enameled) steel reactor
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process

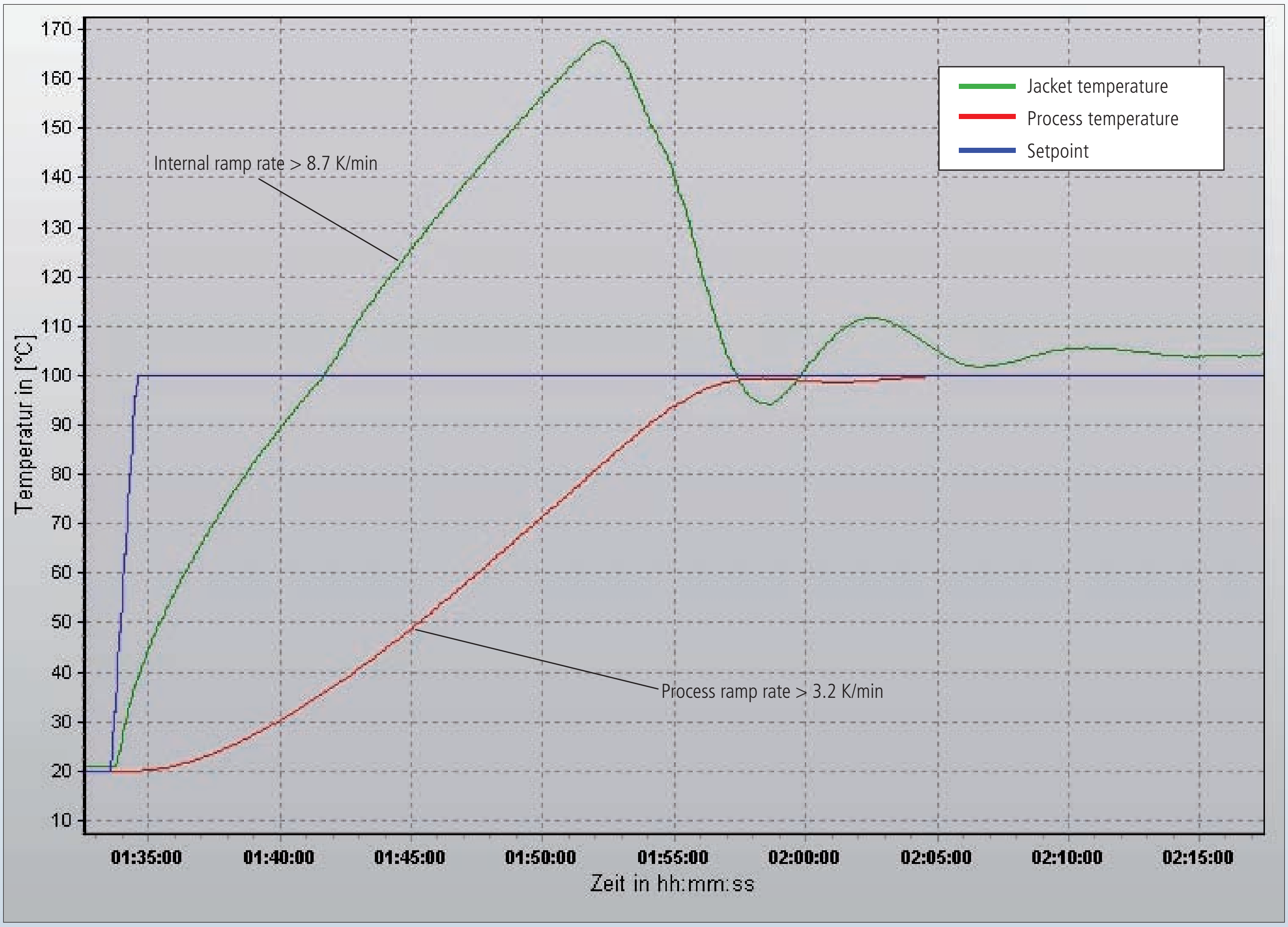
Unistat® 930w

Heating ramp on a 100-litre GLSS jacketed reactor

Requirement
The case study demonstrates the heating curve of a Unistat® 930w working with a 100-litre reactor between 20 °C and 100 °C.

Method
The Unistat® and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The "internal" (jacket) temperature increases rapidly to approx. 167 °C in just 19 minutes and brings the process temperature to the set-point with negligible over-/undershoot within 25 minutes.



Version: 9/2009

Unistat® 930w

"Internal" (jacket) control with a Büchi CR101 GLSS reactor from 20 °C to T_{min} and then to 180 °C

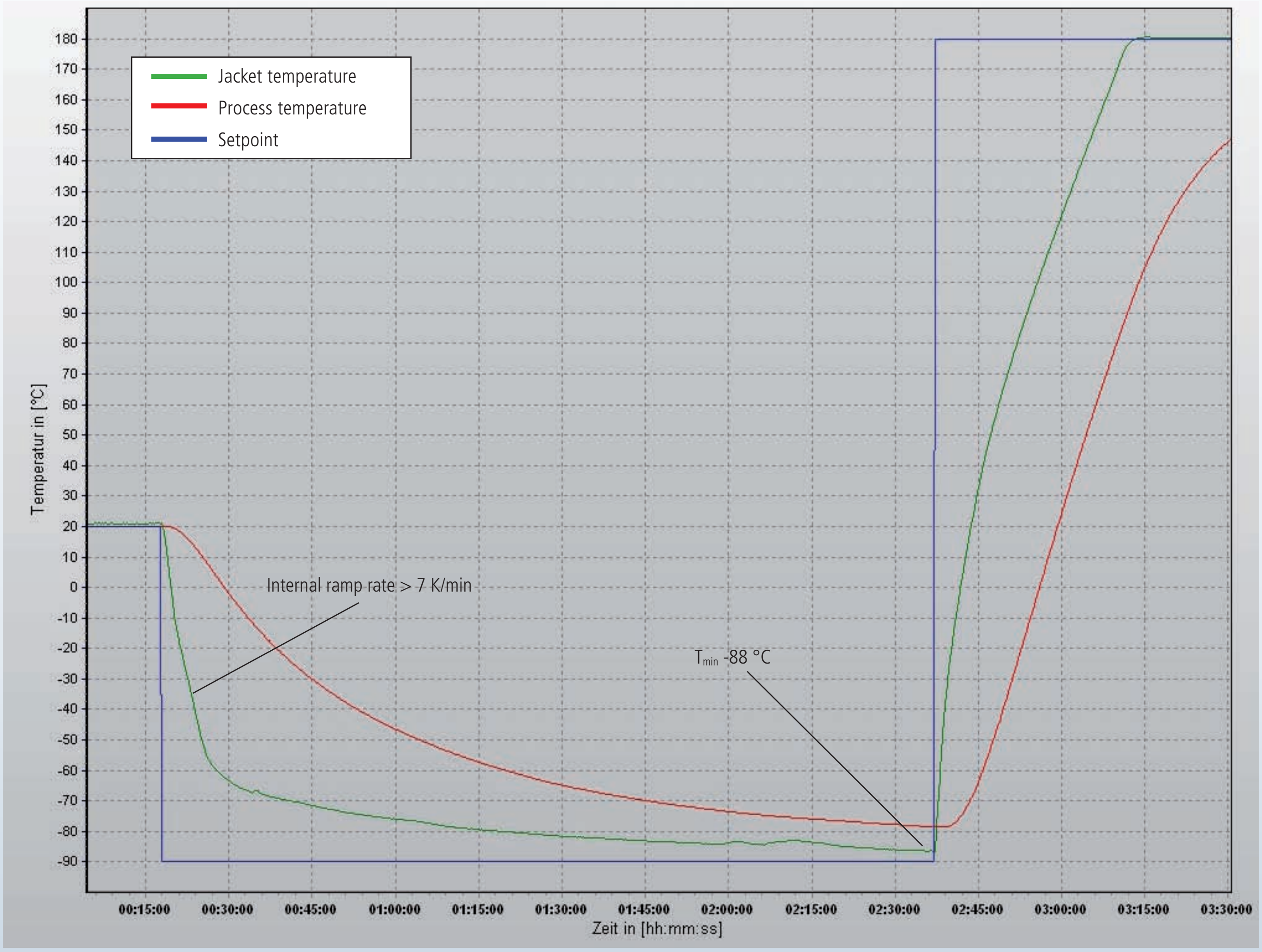
Requirement
The case study shows the performance of a Unistat® 930w working with a Büchi CR101 reactor between a temperature range of -90 °C and 180 °C.

Method
The Unistat® 930w and reactor are connected using two 2-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
Within 12 minutes of set-point change the internal temperature cools rapidly from 20 °C to -65 °C representing a ramp rate > 7 K / min. The ramp rate slows and after 2 ½ hours reaches "T_{min}" of -88 °C.
The set point is then changed to 180 °C and with an average ramp rate of 6 K / min, heats through 268 K in 45 minutes.

Setup details
Unistat® 930w & 100-litre Büchi «chemReactor» CR101 (büchiglasuster)

Temperature range:	-90...200 °C
Cooling power:	20 kW @ 0…-40 °C 15 kW @ -60 °C 5 kW @ -80 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre glass-lined (enameled) steel reactor
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	internal



Version: 9/2009

Setup details
Unistat® 930w & 100-litre Büchi «chemReactor» CR101 (büchiglasuster)

Temperature range:	-90...200 °C
Cooling power:	20 kW @ 0…-40 °C
	15 kW @ -60 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre glass-lined (enameled) steel reactor
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	80 rpm
Control:	process

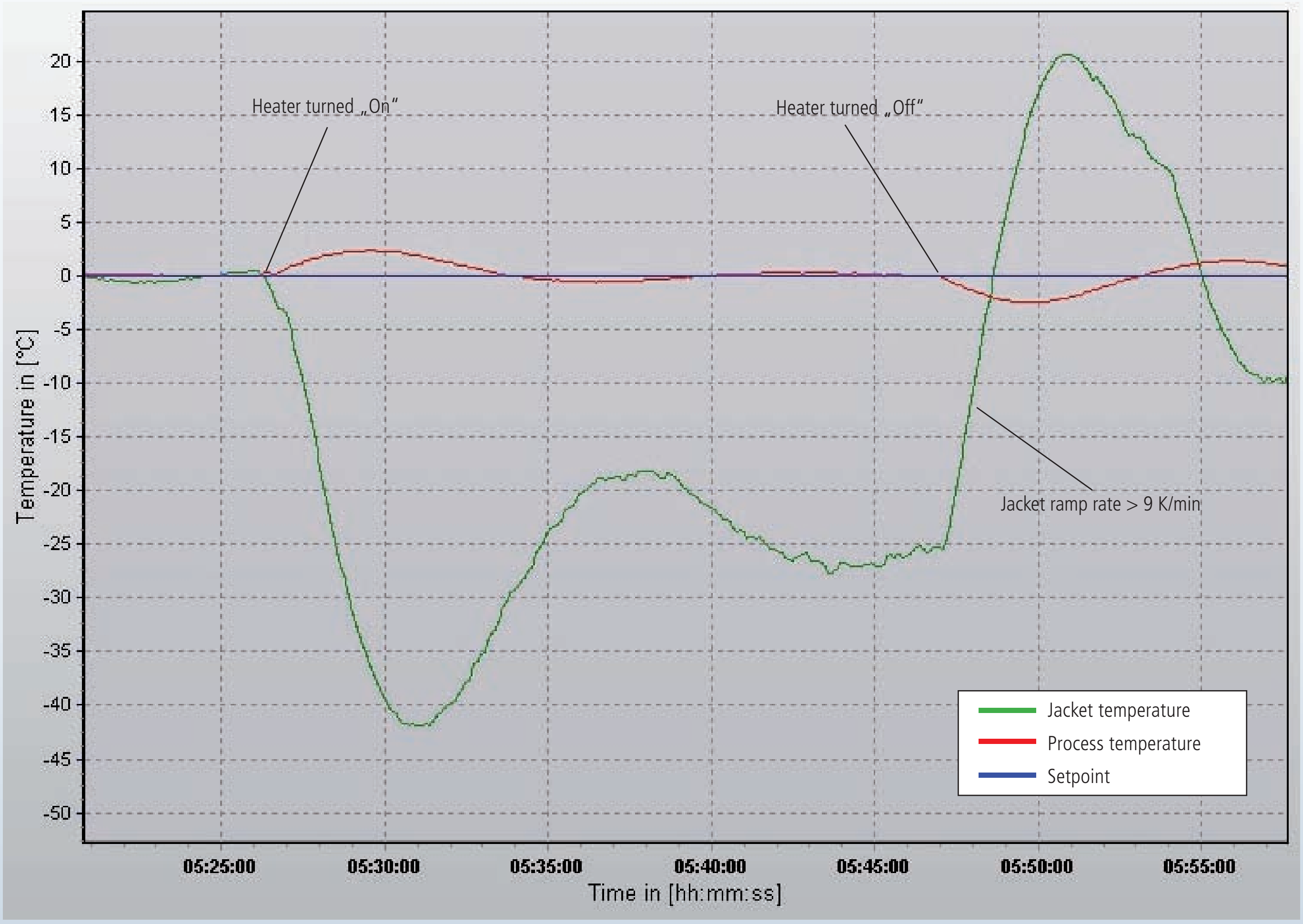
Unistat® 930w

Controlling an exothermic reaction in a Büchi CR101 GLSS reactor

Requirement
A 2.38 kW (2047 kcal / hr) exothermic reaction is simulated at 0 °C in a 100-litre reactor to determine how quickly the Unistat® 930w reacts to control the process at set-point.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
When the control system detects an increase in process temperature it reacts immediately to create a ΔT between process and jacket temperature to induce heat flow. The „internal" (jacket) temperature ramps rapidly to approx. -42 °C to bring the process temperature back to the set-point.



Version: 9/2009

Unistat® 930w

Cooling a Diehm 100-litre glass reactor to T_{min}

Requirement

This case study shows the performance of a Unistat® 930w connected to a 100-litre Diehm glass reactor cooling from 20 °C to T_{min} under "internal" (jacket) control.

Method

The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

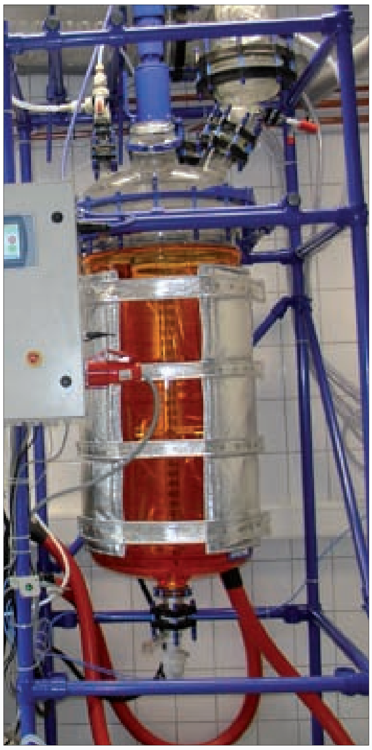
Results

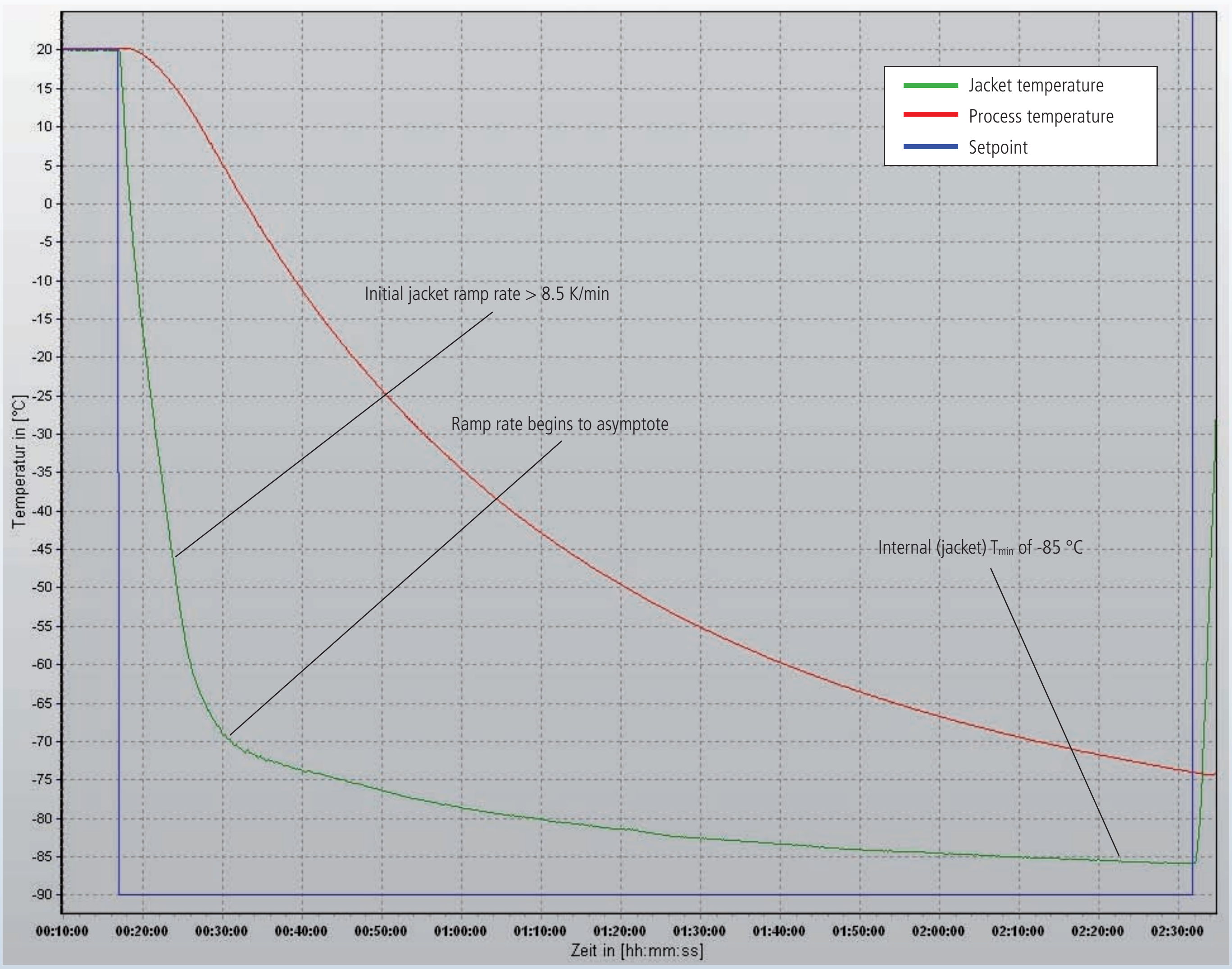
The test is run for 2 hours. The initial „internal" (jacket) ramp rate of over 8.5 K / min rapidly cools the jacket from 20 °C to -70 °C in approximately 12 minutes with a corresponding process ramp rate averaging 2.2 K / min.
After 2 hours the minimum internal temperature reached is -85 °C with a corresponding process temperature of -71 °C though it is continuing to cool towards the "internal" (jacket) temperature.

Setup details

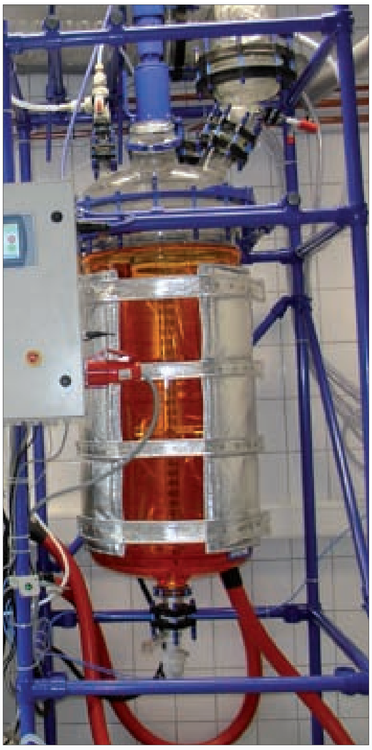
Unistat® 930w & Diehm reactor

Temperature range:	-90...200 °C
Cooling power:	20 kW @ 0…-40 °C 15 kW @ -60 °C 5 kW @ -80 °C
Heating power:	24 kW
Hoses:	2x1 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre un-insulated glass reactor VPC Bypass installed
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	400 rpm
Control:	internal





Version: 9/2009



Setup details
Unistat® 930w & Diehm reactor

Temperature range:	-90...200 °C
Cooling power:	20 kW @ 0…-40 °C
	15 kW @ -60 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre un-insulated glass reactor
	VPC Bypass installed
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	400 rpm
Control:	process

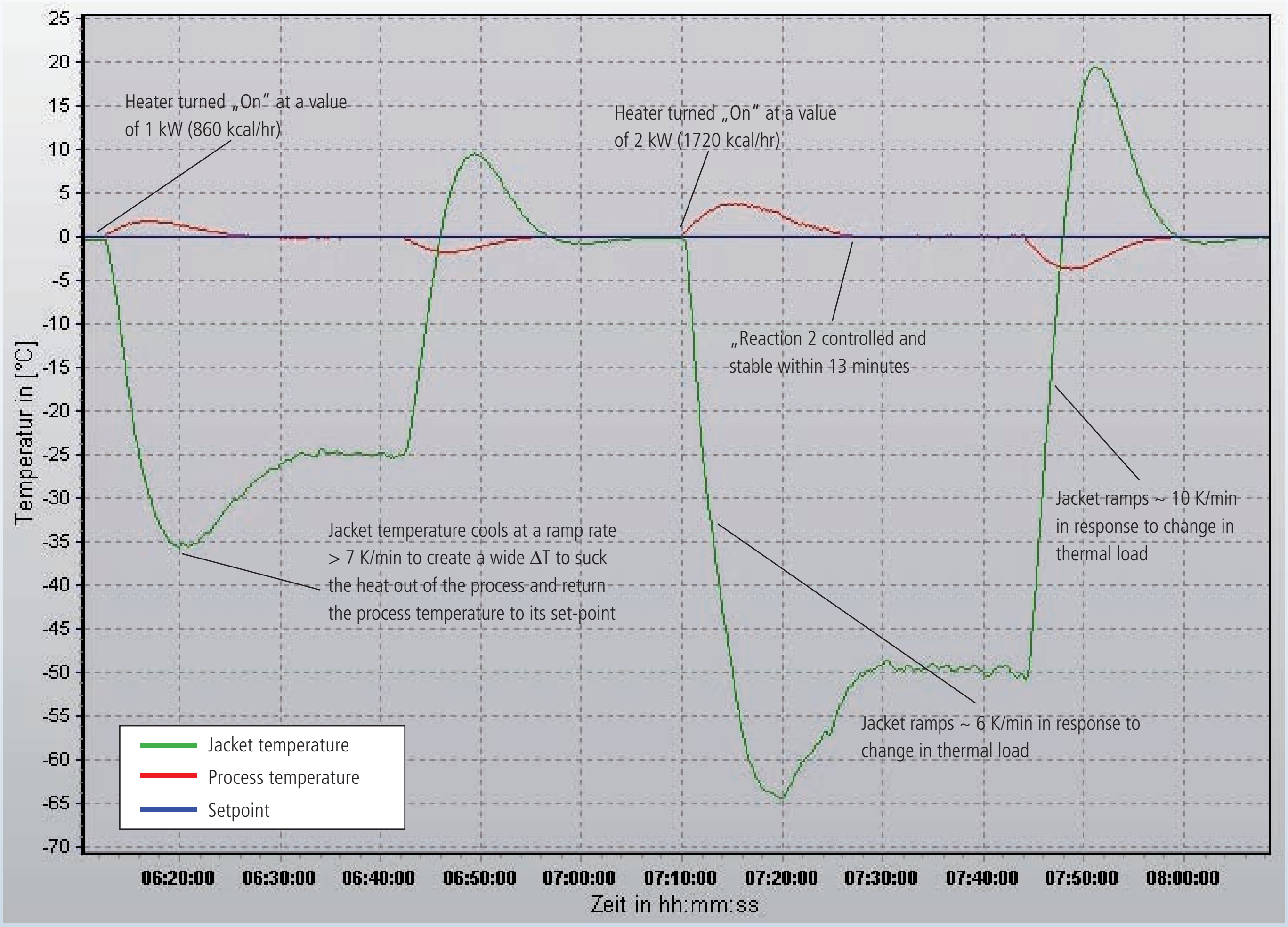
Unistat® 930w

Controlling simulated exothermic reactions of 1 kW (860 kcal / hr) & 2 kW (1720 kcal / hr) in a Diehm 100-litre reactor

Requirement
This case study is to see the performance of a Unistat® 930w as it works to control simulated exothermic reactions in a 100-litre reactor.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The response of the Unistat® 930w can be seen in the graphic below. The jacket temperature is rapidly changed to control the "reaction" and maintain process temperature at its set-point.



Version: 9/2009

Unistat® 930w

Cooling a Diehm 100-litre reactor to -60 °C

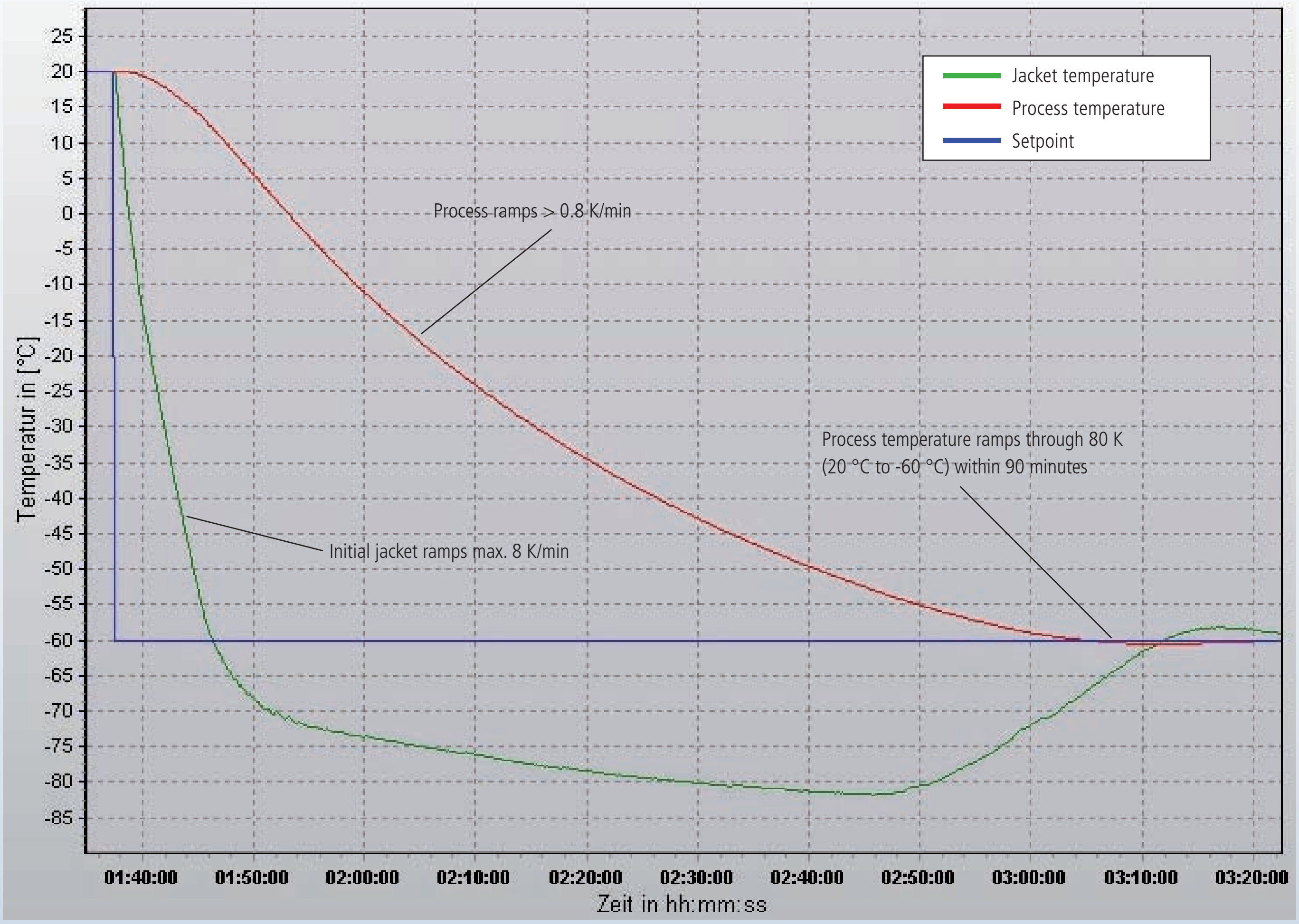
Requirement
This case study is to demonstrate the performance of a Unistat® 930w as it cools a Diehm 100-litre jacketed glass reactor to -60 °C.

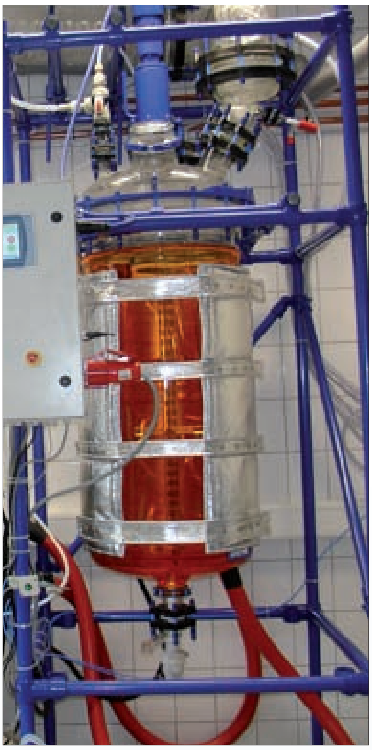
Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
The jacket is ramped rapidly down and the growing ΔT between the process temperature and jacket temperature cools the process smoothly to its set-point.

Setup details
Unistat® 930w & Diehm reactor

Temperature range:	-90...200 °C
Cooling power:	20 kW @ 0…-40 °C 15 kW @ -60 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre un-insulated glass reactor VPC Bypass installed
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	400 rpm
Control:	process





Unistat® 930w

Heating and cooling a Diehm 100-litre reactor under different control dynamics

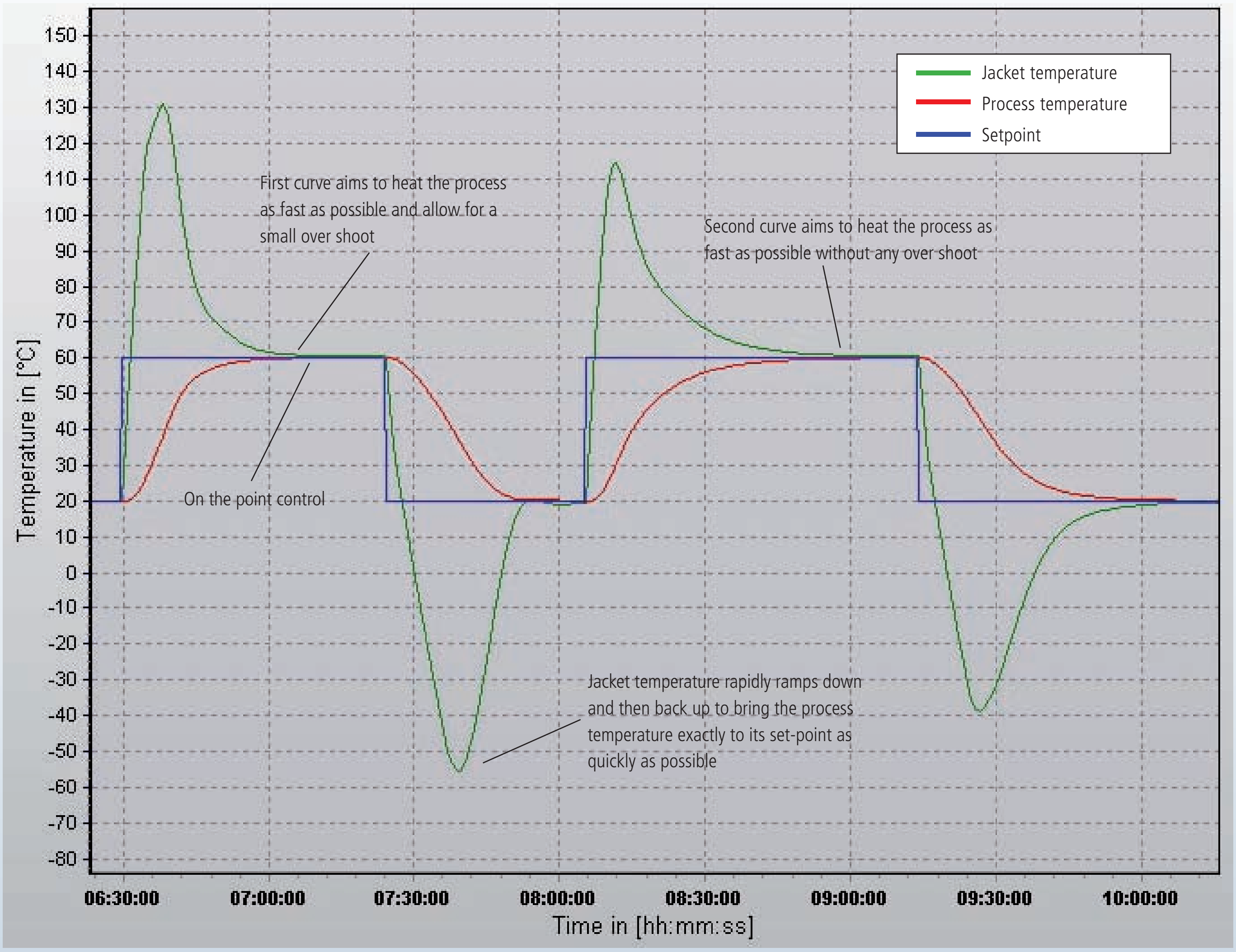
Requirement
This case study looks at the performance of a Unistat® 930w heating and cooling a Diehm 100-litre reactor from 20 °C to 60 °C under two different control dynamics;
– Fast, small overshoot
– No overshoot

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
Fast, small overshoot – even under this control dynamic it can be seen that the process temperature reaches the set-point of 60 °C with negligible overshoot.
No overshoot – here the ramp rates are slower to minimise the overshoot. It can be seen that the ΔT generated between jacket and process are narrower so change in process temperature is slower.

Setup details
Unistat® 930w & Diehm reactor

Temperature range:	-90...200 °C
Cooling power:	19 kW @ 200…100 °C 20 kW @ 0…-40 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre un-insulated glass reactor VPC Bypass installed
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	400 rpm
Control:	process



Version: 9/2009

Unistat® 930w

Thermal shock protection shown on a Diehm 100-litre reactor

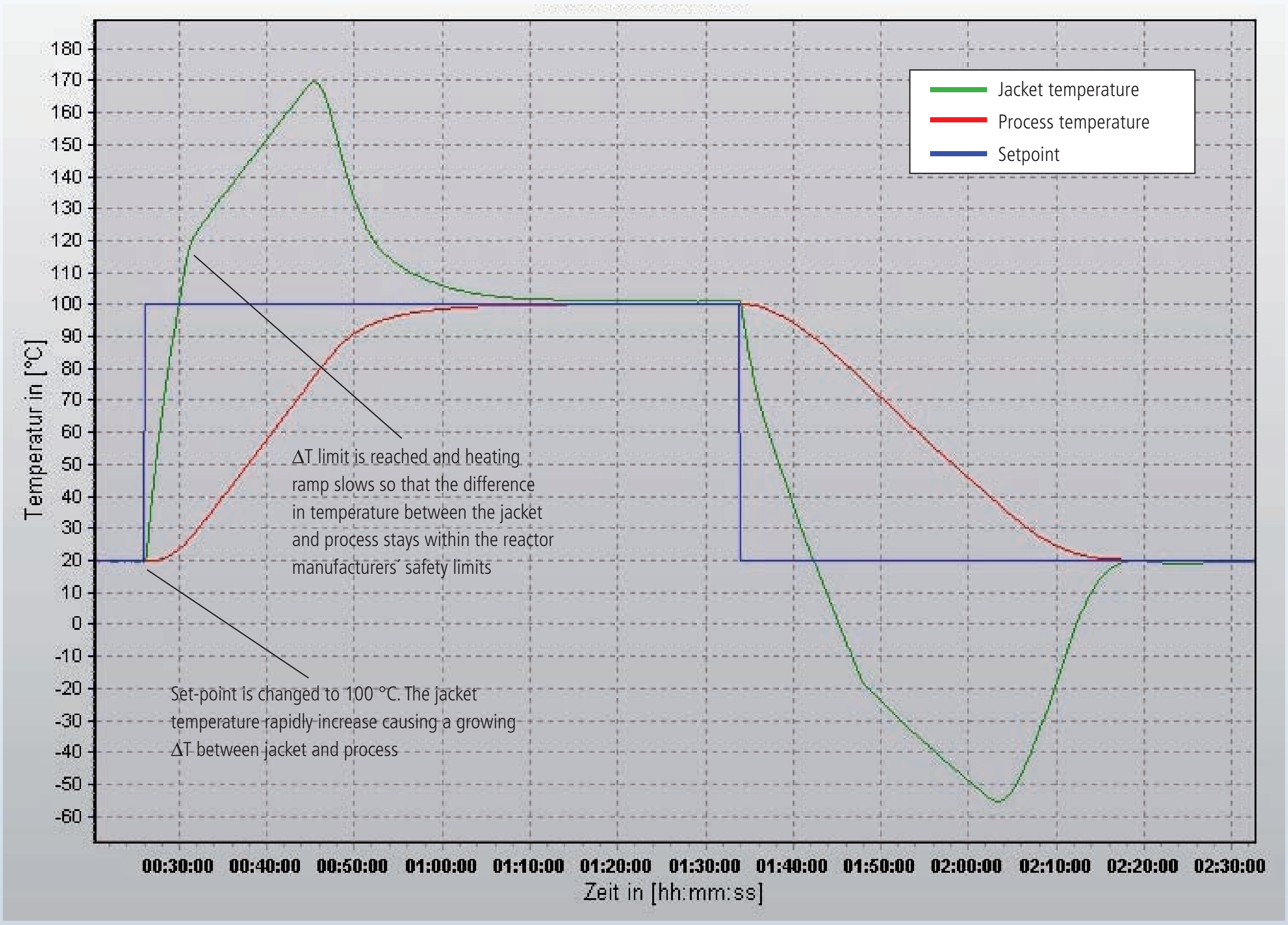
Requirement
This case study is designed to show the function of 'ΔT limit' in the controller and how it protects glass reactors against thermal shock. This Diehm glass reactor does not have a manufactures ΔT limit at all. We could see in our tests > 150 K ΔT.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

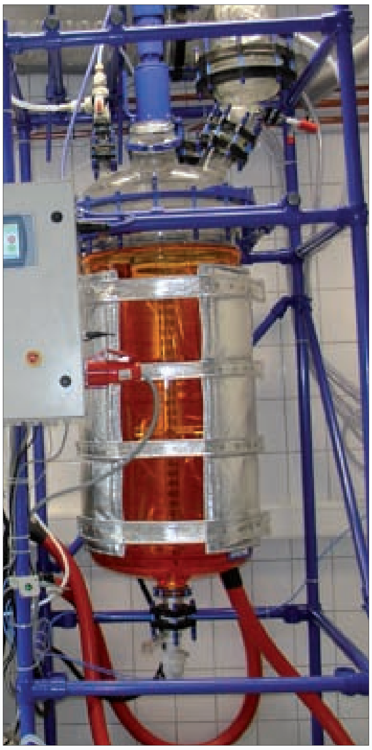
Results
A standard user defined feature in the Unistats® is the "ΔT limit" which limits the difference in temperature between the process and reactor jacket. It is set by the user to a value recommended by the reactor manufacturer. The default setting is 100 K.
The process temperature ramps at a rate of 3.53 K / min and reaches the set-point in 47 minutes. Meanwhile the cooling ramps at a rate of 2.3 K / min and takes 53 minutes to reach 20 °C.
Throughout the whole process the reactor is protected.

Setup details
Unistat® 930w & Diehm reactor

Temperature range:	-90...200 °C
Cooling power:	19 kW @ 200…100 °C 20 kW @ 0…-40 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre un-insulated glass reactor VPC Bypass installed
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	400 rpm
Control:	process



Version: 9/2009



Unistat® 930w

Accurate & safe control of a Diehm 100-litre glass reactor

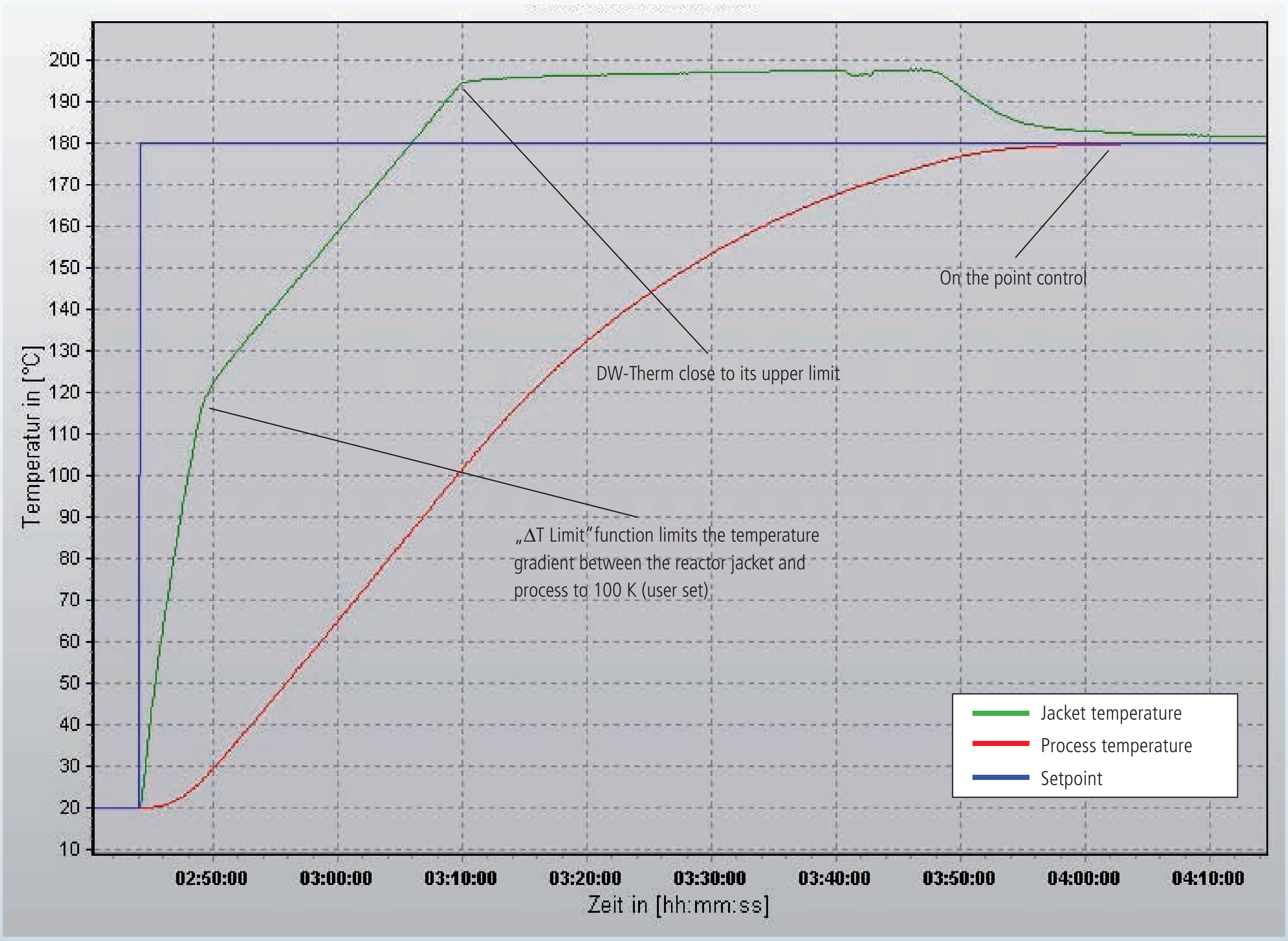
Requirement
This case study looks at the performance of a Unistat® 930w heating a 100-litre reactor to 180 °C.
The HTF used is "DW-Therm" which has an upper temperature limit of 200 °C so the jacket temperature (HTF temperature) must remain below this limit.

Method
The Unistat® and reactor are connected using two 1.5-metre insulated metal hoses. The reactor is filled with 75 litre of "M90.055.03", a Huber supplied silicon based HTF.

Results
It can be seen that the jacket rapidly heats to close to the limit of the DW-Therm while the process temperature ramps smoothly to its setpoint of 180 °C.
In addition to the limit imposed by the upper limit of DW-Therm, the reactor is also protected against thermal shock by the user set "ΔT limit". In this case the ΔT limit is set to 100 K. This ensures that the temperature gradient between the reactors jacket and the process never exceeds 100 K.

Setup details
Unistat® 930w & Diehm reactor

Temperature range:	-90...200 °C
Cooling power:	19 kW @ 200…100 °C 20 kW @ 0…-40 °C
Heating power:	24 kW
Hoses:	2x1.5 m; M38x1.5 (#6656)
HTF:	DW-Therm (#6479)
Reactor:	100 litre un-insulated glass reactor VPC Bypass installed
Reactor content:	75 litre M90.055.03 (#6259)
Stirrer speed:	400 rpm
Control:	process



Version: 9/2009

Unistat®
1005w

Unistat® 1005w cooling an Asahi 10-litre triple wall reactor to -110 °C

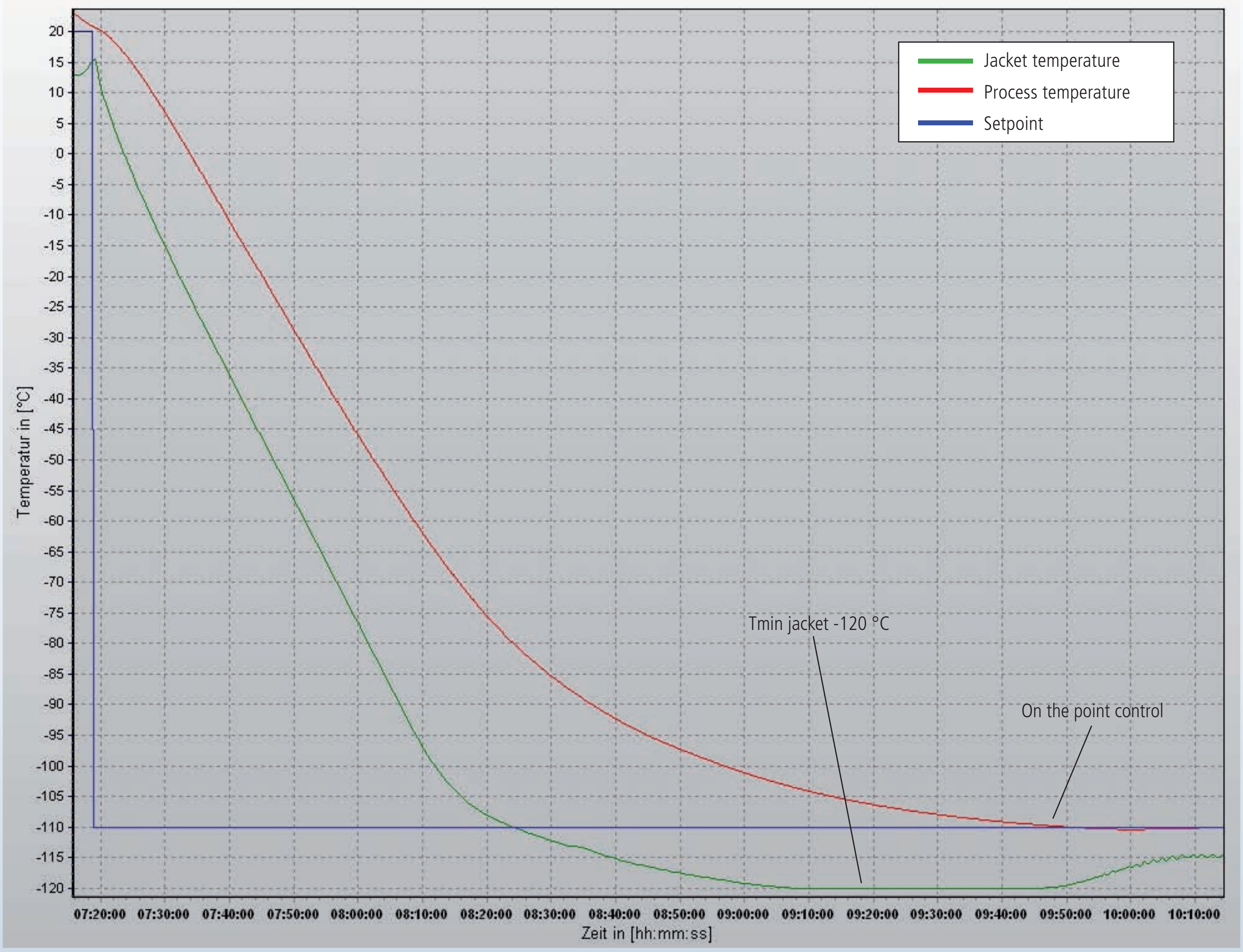
Requirement
Temperatures required to carry out chemistry in specialised cryogenic research have become lower and lower. This case study demonstrates that the process temperature inside an Asahi vacuum insulated glass reactor can be comfortably cooled and controlled at -110 °C by using a Unistat® 1005w.

Method
The Asahi reactor was connected to the Unistat® 1005w using two 2-metre M30 x 1.5 insulated metal hoses. Under process control, a process set-point of -110 °C was entered and the results recorded using the Huber "Spyware".

Results
The jacket temperature cools quickly in a linear fashion to -100 °C in approximately 55 minutes (ramp rate of 2 K/min) before slowing and reaching a "T_{min}" of -120 °C. The process temperature follows and reaches -110 °C in 150 minutes and is maintained at -110 °C with the jacket temperature at -115 °C.

Setup details
Unistat® 1005w

Temperature range:	-120...100 °C
Cooling power:	1.5 kW @ 100…-40 °C 1.4 kW @ -60… -80 °C 1.0 kW @ -100°C
Heating power:	2.0 kW
Hoses:	2 x1.5 m; M30x1.5 (#6386)
HTF:	Kryothermal S
Reactor:	10-litre insulated jacketed glass reactor
Reactor content:	10 litre M90.055.03
Stirrer speed:	~ 200 rpm
Control:	process



Applikationsbericht:

Vergleich der Kühlleistungen von Huber Unistat® 510w und einem Wettbewerbs-Temperiersystem

In diesem Anwendungstest wurden die Kühlleistungen der beiden Thermostaten „Huber Unistat® 510w“ und dem Wettbewerbsmodell“ getestet und miteinander verglichen.
Angeschlossen waren beide Geräte an einen 20 L HWS Doppelmantel-Glasreaktor ohne äußere Isolierung. Als Temperierflüssigkeit wurde jeweils das Weitbereichstemperaturöl „Julabo Thermal H5S“ verwendet, welches in geschlossenen Systemen für Temperaturen von -40 °C bis 250 °C ausgelegt ist.

Der Vergleich umfasst drei Testläufe:
1. Kühlen von 10 L Ethanol von 20 °C auf -20 °C.
2. Schnelle Zugabe von 5 L 20 °C warmes Ethanol zu den 10 L auf - 20 °C gekühltes Ethanol (Test auf Exothermie, d.h. einer plötzlichen Erhöhung der Innentemperatur),
3. Kühlen der insgesamt 15 L Ethanol von -20 °C auf -40 °C.

Die Daten der Testläufe wurden über die jeweiligen RS232-Schnittstellen der Thermostaten ausgelesen und mit Hilfe der mitgelieferten Software von Huber bzw. Wettbewerbsmodell auf einem Computer aufgezeichnet.

evtl. Foto von Merck (Reaktor)
=> Hr. Kaltwasser / MKE

Setup details
Unistat® 510w & HWS reactor

Temperature range:	-50...250 °C
Cooling power:	5.3 kW @ 250...0 °C
	2.8 kW @ -20 °C
	0.9 kW @ -40 °C
	maximale Pumpendrehzahl
Heating power:	6.0 kW
Hoses:	2x1 m; M38x1.5 (#6655)
HTF:	Julabo Thermal H5S
Reactor:	un-insulated 20 litre HWS glass reactor
Reactor content:	10 litre Ethanol
Stirrer speed:	150 rpm
Control:	process

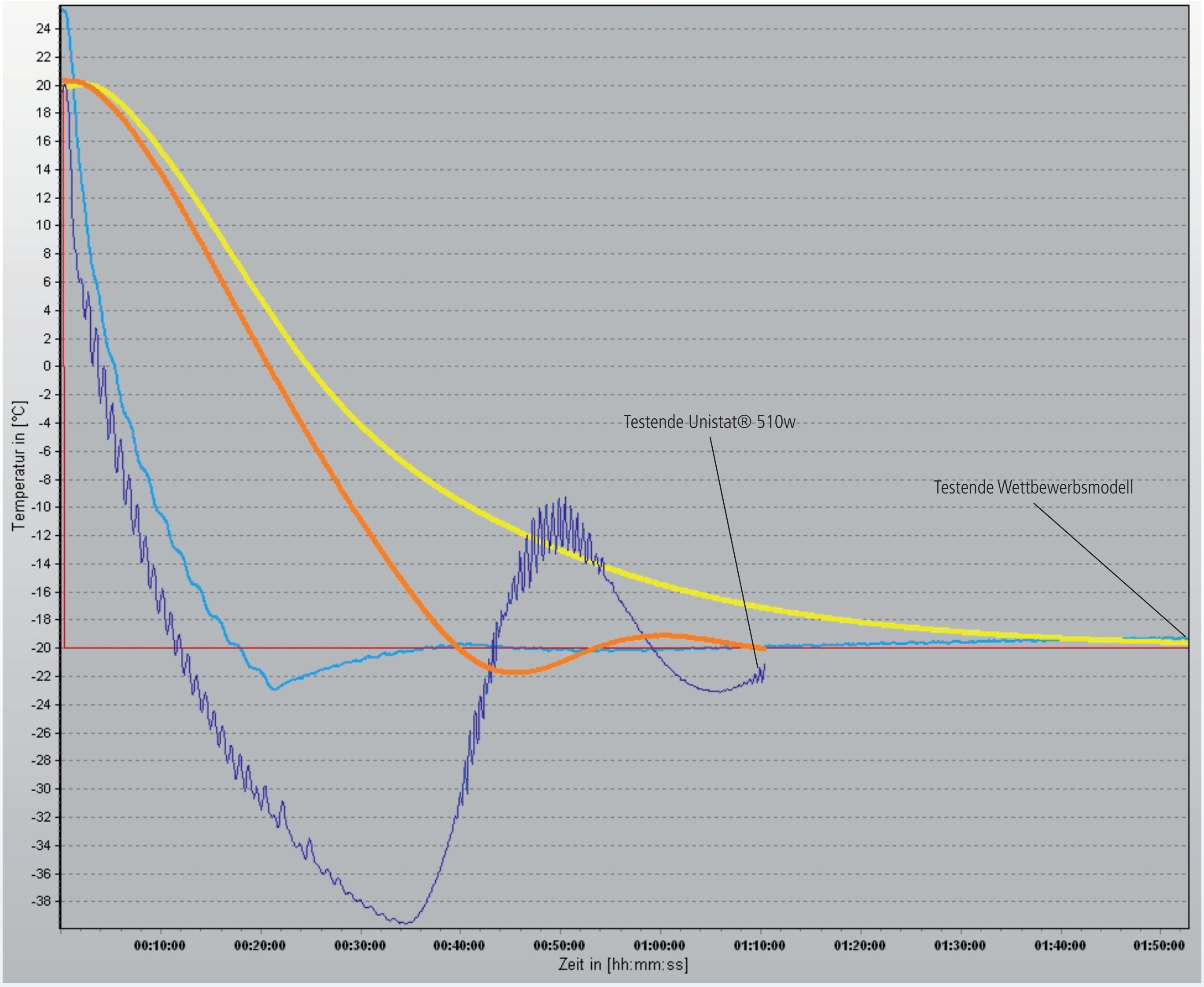
Setup details
Wettbewerbsmodell & HWS reactor

Temperature range:	-50...250 °C
Cooling power:	5.5 kW @ 200 °C
(version:	7 kW @ 20 °C
	2.8 kW @ -20°C
	0.9 kW @ -40 °C
	je auf Pumpenstufe 1 gemessen
Heating power:	6.0 kW
Hoses:	2x1 m; M38x1.5 (#6655)
HTF:	Julabo Thermal H5S
Reactor:	un-insulated 20 litre HWS glass reactor
Reactor content:	10 litre Ethanol
Stirrer speed:	150 rpm
Control:	process

Version: 9/2009

1. Kühlen von 10 L Ethanol von Raumtemperatur (20 °C) auf -20 °C.

Die Ergebnisse des Abkühlens von 10 L Ethanol von Raumtemperatur auf -20 °C sind in Bild 1 dargestellt.

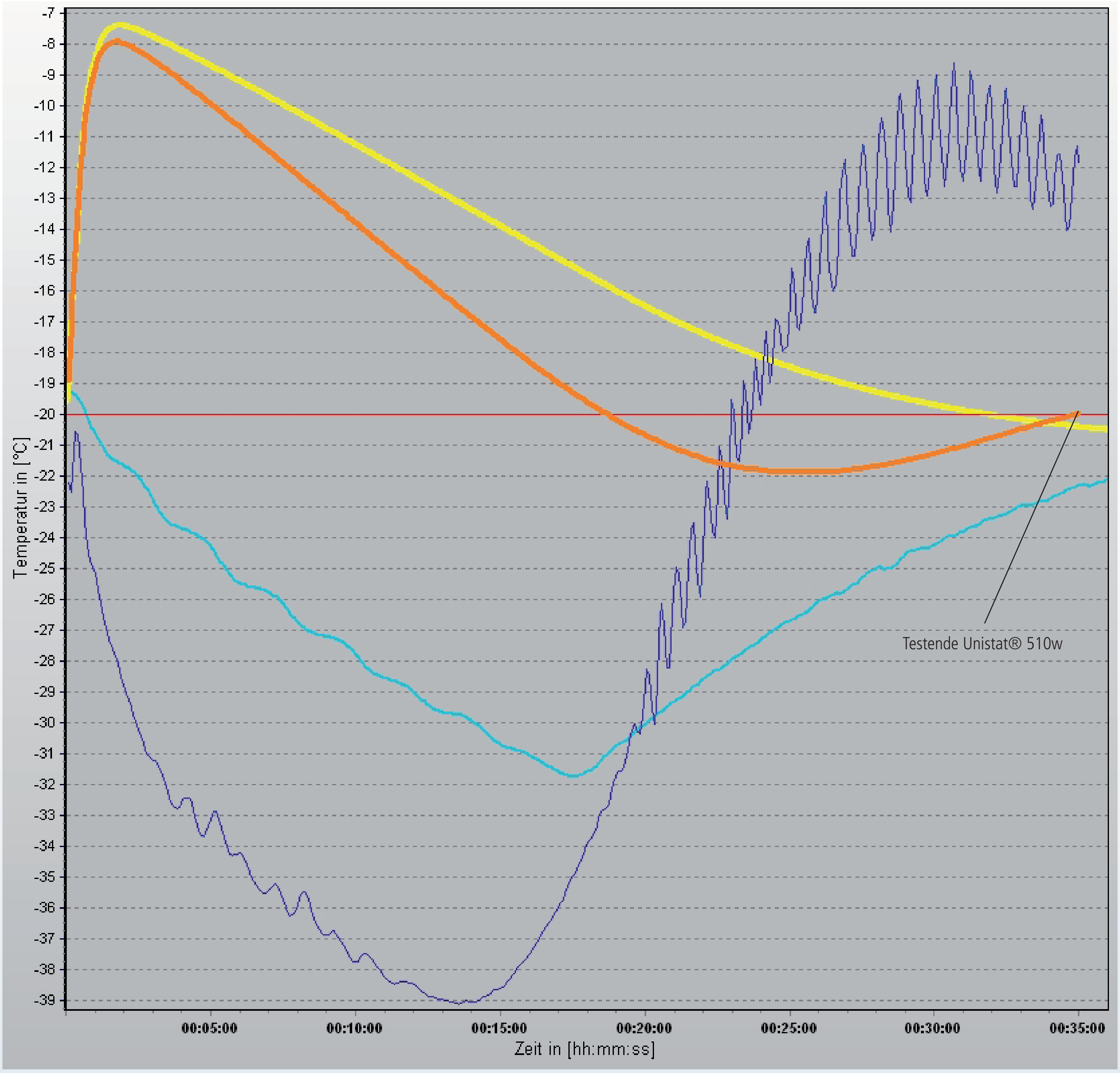


Der Unistat® 510w kühlt sowohl das Öl (dunkelblaue Kurve) als auch das Ethanol (orange Kurve) von Anfang an etwas schneller runter als das Wettbewerbsmodell (blaue bzw. gelbe Kurve). Die vorgegebene Endtemperatur wird mit dem Huber-Gerät schon nach etwa 40 Min. erreicht. Zu diesem Zeitpunkt beträgt die Innentemperatur beim Wettbewerbsmodell lediglich -9.5 °C. Das schnellere Erreichen der Endtemperatur ist neben einer etwas besseren Kühlleistung auch darauf zurückzuführen, dass der Unistat® 510w stärker „untersteuert" (Öltemperatur geht bis fast auf -40 °C nach ca. 30 Min., she. dunkelblaue Kurve) als das Wettbewerbsmodell (blaue Kurve). Durch eine schnelle Anpassung der Öltemperatur schafft es der Unistat® 510w dennoch, die Innentemperatur nicht deutlich unter die eingestellten -20 °C kommen zu lassen (s. dunkelblaue und orange Kurve bei 33-40 Min.).

Darf die vorgegebene Temperatur allerdings keinesfalls unterschritten werden, müssten die Geräteeinstellungen angepasst werden (oder in Etappen abgekühlt werden), wodurch der Unterschied zwischen beiden Thermostaten sicherlich geringer ausfällt.

2. Test auf Exothermie durch schnelle Zugabe von 5 L 20 °C warmen Ethanol.

Noch entscheidender wirkt sich die bessere Kühlleistung des Unistat® 510w bei einer nachgestellten plötzlich auftretenden Exothermie - also einer sprunghaften Erhöhung der Innentemperatur im Reaktor - aus (she. Bild 2). Bei diesem Test wurden zu den 10 L auf -20 °C gekühltem Ethanol in weniger als 1 Min. 5 L Raumtemperatur-warmes (20 °C) Ethanol gegeben.

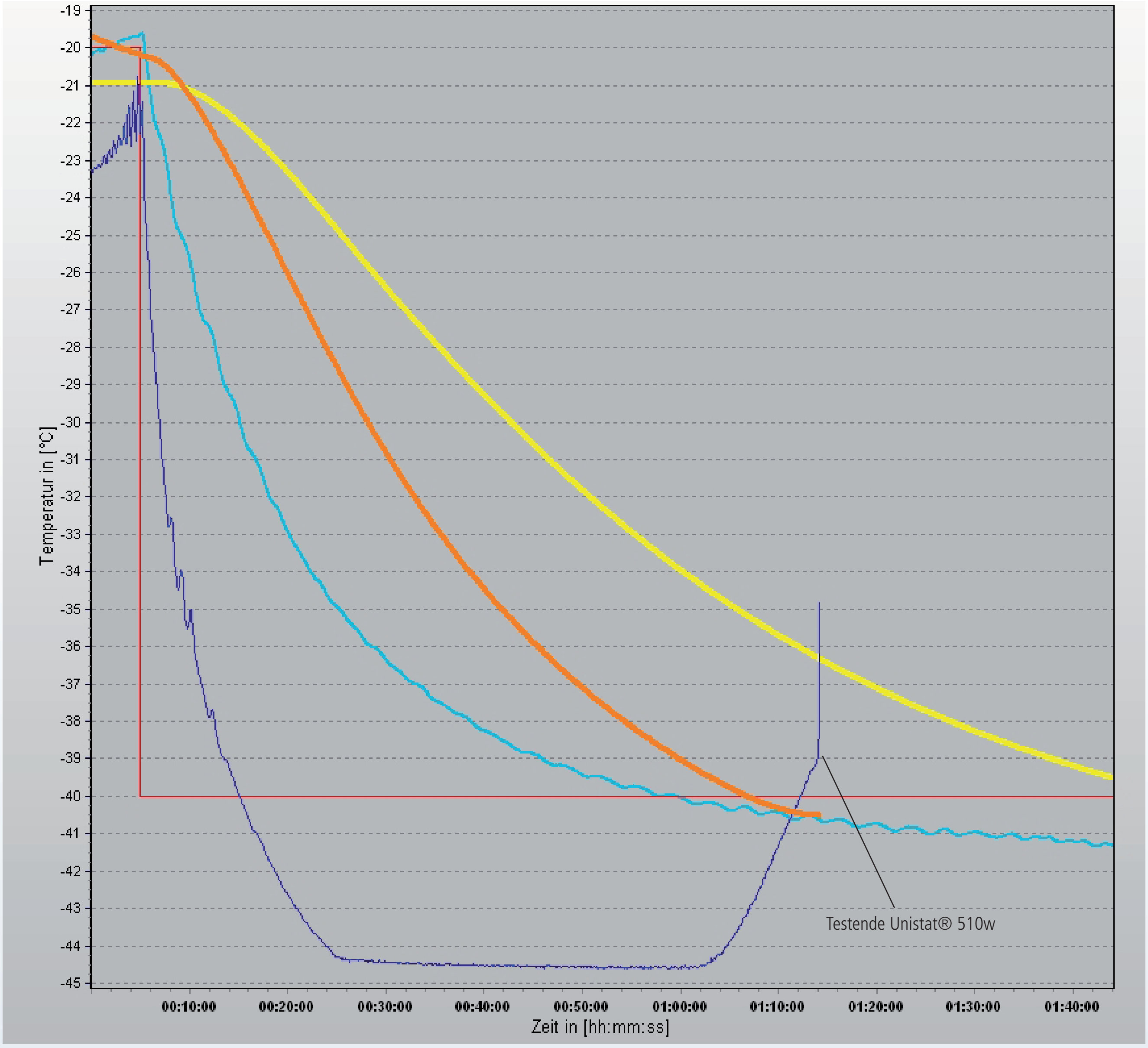


Das Huber-Gerät reagiert sehr schnell auf die eintretende Erhöhung der Innentemperatur und kühlt schon nach wenigen Minuten mit -30 °C bis fast -40 °C im Öl dagegen an (she. dunkelblaue Kurve). Das Wettbewerbsmodell braucht hingegen deutlich länger um die Öltemperatur auf unter -30 °C zu bringen (she. blaue Kurve), obwohl beide Geräte in den ersten Minuten mit voller Leistung kühlen (nicht dargestellt). Dies bewirkt, dass die maximale Temperaturerhöhung beim Huber-Gerät etwas geringer ist. Vor allem aber geht die Innentemperatur beim Unistat® 510w signifikant schneller zurück (vgl. orange und gelbe Kurve) und ist schon nach knapp 19 Min. wieder auf den gewünschten -20 °C. Mit dem Wettbewerbsmodell ist die Innentemperatur zu diesem Zeitpunkt noch mehr als 4 °C höher, die -20 °C werden hier erst nach über 30 Min. wieder erreicht. Diese Ergebnisse bedeuten nach unserer Auffassung, dass das Huber-Gerät schneller und besser auf plötzlich auftretende Temperaturerhöhungen reagiert und somit eher die Möglichkeit hat, ein „Durchgehen" von exothermen Reaktionen abzufangen bzw. deren Auswirkungen zu minimieren.

Version: 9/2009

3. Kühlen der insgesamt 15 L Ethanol von -20 °C auf -40 °C

Als dritten Test in dieser Reihe haben wir versucht, die nun insgesamt 15 L Ethanol von -20 °C auf -40 °C zu kühlen (she. Bild 3).



Auch hier zeigt sich die bessere Kühlleistung des Unistat® 510w sowohl in den Öl- (blaue Kurven) als auch in den Innentemperaturen (orange bzw. gelbe Kurve). Die Öltemperatur des Huber- Geräts unterschreitet schon nach weniger als 15 Min. die -40°C Marke, während das Öl des Wettbewerbs-Geräts zu diesem Zeitpunkt erst auf etwa -30 °C im Öl gekühlt ist. Entsprechend sind die 15 L Ethanol mit dem Unistat® 510w schon nach etwas über einer Stunde auf -40 °C gekühlt - mit dem Wettbewerbsmodell ist die Innentemperatur zu diesem Zeitpunkt noch fast 5 °C höher. Die vorgegebenen -40 °C sind hier erst nach 1:45 h annähernd erreicht.

4. Fazit

Das Fazit dieser Testreihe ist für uns, dass

1. der Unistat® 510w von Huber trotz gleicher Leistungsangaben im Katalog eine bessere Kühlleistung hat, und
2. der Unistat® 510w schneller auf Temperaturänderungen im Reaktor reagieren kann und damit z.B. eher die Möglichkeit hat, plötzlich eintretende Exothermien abzufangen bzw. deren Auswirkungen zu minimieren.

Als Grund für die Unterschiede zwischen den beiden Thermostaten sehen wir die geringere Menge an benötigtem Öl beim Unistat® 510w. Während das Wettbewerbsmodell (inkl. Öl im Reaktormantel und Schläuchen) ca. 24 L Temperierflüssigkeit benötigte, kam der Unistat® 510w mit insgesamt 11 L aus. Abschließend möchten wir noch zwei Aspekte erwähnen, die uns bei dem Applikationstest mit dem Huber-Thermostaten positiv aufgefallen sind: Zum einen das geringe Betriebsgeräusch des Unistat® 510w und zum anderen die sehr intuitive Bedienung über das Touch-Display. Insgesamt hat der Huber Unistat® 510w diesen Applikationstest damit mit Bravour bestanden.

Unistat®
Tango Nuevo

Unistat® Tango Nuevo

This is a 14 hour run using Atlas software (1.4) to control the temperature of a 1-litre reactor containing 500 mls organic solvent (silicone oil) following a complex thermal profile using a standard Huber Unistat® "Tango Nuevo".
In this case, the "TAC" control is not being used. To tailor the Unistat® Tango Nuevo, the PID parametres have been chosen to give the best possible response to this application.

The plot shows:
- Atlas reactor temperature in red
- Circulator temperature in blue
- Requested circulator set-point in green
- Actual desired set-point profile in blue line

Version: 9/2009

Unistat® Tango Nuevo

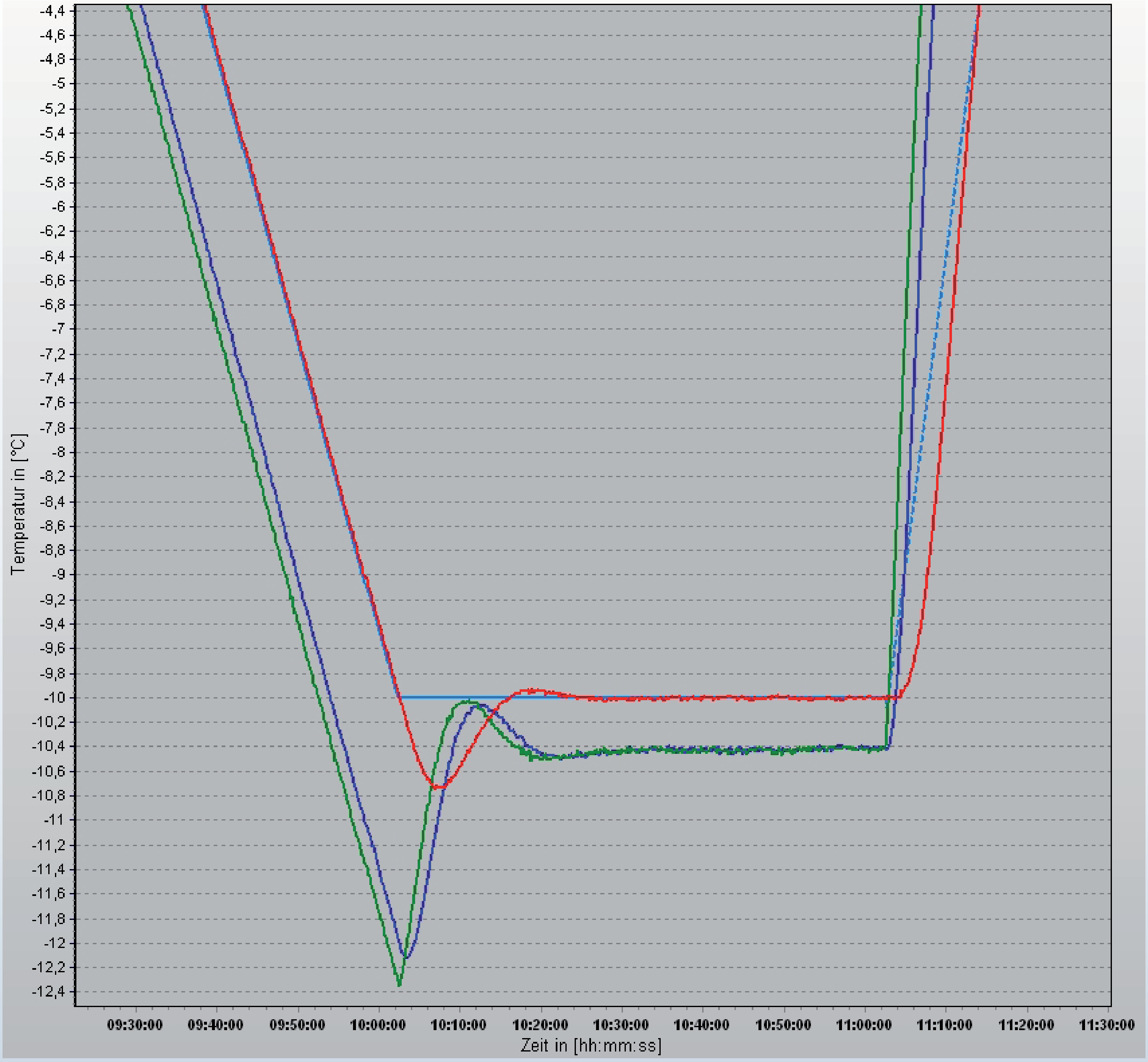
Unistat® Tango Nuevo

The inserted magnified graphic shows details of the section between 10:00 and 11:00. It can be clearly seen how accurately the Atlas system combined with the fast response of the Tango Nuevo controls the HTF temperature and hence the Atlas reactor.
The programmed ramp rates are executed with precision as are the dwell periods giving the operator the requested thermal profile exactly as it was programmed.

Setup details

Unistat® 1005w

Temperature range:	-120...100 °C
Cooling power:	1.5 kW @ 100…-40 °C 1.4 kW @ -60… -80 °C 1.0 kW @ -100°C
Heating power:	2.0 kW
Hoses:	2 x2 m; M30x1.5 (#6386)
HTF:	Kryothermal S
Reactor:	10-litre insulated jacketed glass pressure reactor
Reactor content:	10 litre M90.055.03
Stirrer speed:	~ 200 rpm
Control:	process



Version: 9/2009

Top 100 – Innovator 2009

The findings of the latest study have resulted in us being recognised as one of Germany's „Top 100" innovative companies in 2009. Further information can be found at www.huber-online.com.

Peter Huber Kältemaschinenbau GmbH
Werner-von-Siemens-Straße 1
D-77656 Offenburg/Germany
Telephone +49 781 9603-0, Fax +49 781 57211
info@huber-online.com, www.huber-online.com

huber

high precision
thermoregulation