D11.7

Report on Extended Mobile Bypass to Measure the Mass Flow Rate

SFERA II Project	
Solar Facilities for the European Research Area -Second Phase	
Grant agreement number:	312643
Start date of project:	01/01/2014
Duration of project:	48 months
WP11 – Task 11.2	Deliverable 11.7
Due date:	06/2015
Submitted	06/2015
File name:	D11.7_SFERA-II_Deliverable_WP11_UpgradeMass.pdf
Partner responsible	DLR
Person responsible	Marc Röger
Author(s):	Christoph Hilgert, Marc Röger, Stefan Aull
Dissemination Level	Public

List of content

Executive Summary

The EU-funded research project - SFERA - aims to boost scientific collaboration among the leading European research institutions in solar concentrating systems, offering European research and industry access to the best research and test infrastructures and creating a virtual European laboratory. The project incorporates the following activities:

- Transnational Access: Researchers will have access to five state-of-the-art high-flux solar research facilities, unique in Europe and in the world. Access to these facilities will help strengthen the European Research Area by opening installations to European and partner countries' scientists, thereby enhancing cooperation.

- Networking: These include the organisation of training courses and schools' to create a common training framework, providing regularised, unified training of young researchers in the capabilities and operation of concentrating solar facilities. Communication activities will seek to both strengthen relationships within the consortium, creating a culture of cooperation, and to communication to society in general, academia and especially industry what SFERA is and what services are offered.

- The Joint Research Activities aim to improve the quality and service of the existing infrastructure, extend their services and jointly achieve a common level of high scientific quality.

This deliverable 11.7 is one of the results of WP 11, Task 2 - Upgrading of heat capacity measurement facility to calibrate mass flow sensors in existing test facilities - within the Joint Research Activities.

The KONTAS-c_p facility consists of a bypass with electric heating, temperature difference measurement and a Coriolis mass flow sensors to measure the specific thermal heat capacity (c_p) of heat transfer fluid (HTF). During the SFERA-II project, the measurement accuracy of the c_p–measurement is enhanced and an additional Coriolis mass flow sensor is included. This further mass flow rate sensor enables the recalibration of already installed mass flow sensors in a testing facility. The calibration bypass is portable and can be coupled to practically any test facility using thermal oil. Among others, mass flow and specific heat capacity are key measurands to carry out energy balance studies and efficiency measurements in thermal collector assessments.

This deliverable describes the integration of a highly accurate mass flow rate sensor (Coriolis) to the bypass. Most test facilities have inline volume flow or even mass flow measuring devices to carry out energy balance studies. As a matter of fact, such sensors are installed in piping and data acquisition system and thus cannot be taken out easily for calibration or functional checks. Over time, e.g. due to changes in temperature, an initially low measurement uncertainty of an integrated flow or mass flow sensor may change. By connecting the upgraded measurement bypass to facilities, an inline facility sensor can be calibrated and thereby the sensor specific and overall measurement uncertainty is decreased.

This measure in combination with the enhancement of measurement accuracy of heat capacity measurements (deliverable 11.6) lead to a high measurement accuracy of thermal performance tests of CSP components and systems. Thus, European research centres are enabled to offer a more reliable service to users from industry and research.

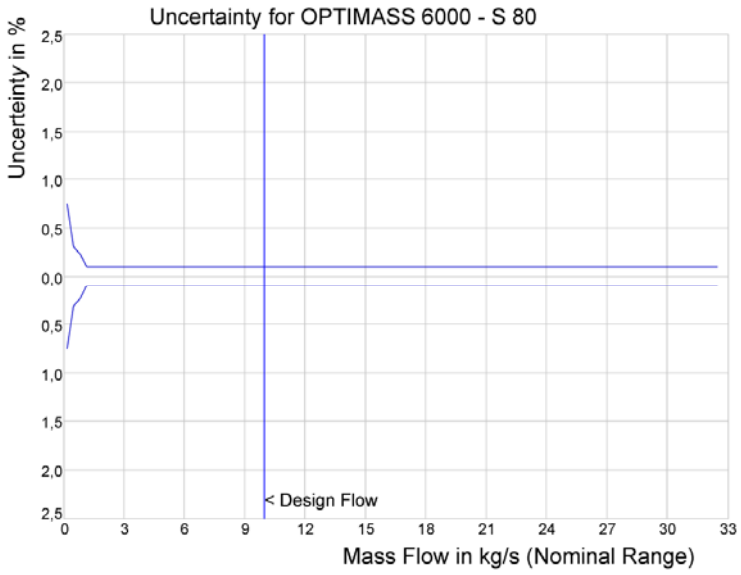
1. Introduction

KONTAS-c_p is a DLR designed and built measurement bypass to precisely and accurately quantify the specific heat capacity of heat transfer fluids (HTFs) like Therminol VP1 and Sylterm 800 under CSP relevant operating conditions. That means temperatures in the range of 20 to 350 °C and pressure up to 18 bars. During the SFERA-II project, its measurement accuracy is enhanced and a highly accurate Coriolis mass flow rate sensor is installed in the bypass. The bypass can be connected to an existing HTF circuit by two flange connections. Relating to data acquisition, it is designed for stand-alone operation. Thus, it operates independently from any plant data acquisition system. For this purpose, the bypass is connected to a laptop computer running a virtual instrument for system control and data acquisition [Hilgert 2012].

Accurate thermal performance testing of CSP components and systems is crucial for the innovation of the CSP technology. The bypass allows to measure the specific heat capacity of HTFs used in testing installations and to recalibrate already installed mass flow rate sensors. The testing installations which are characterized and recalibrated by the bypass are enabled to offer a more reliable performance testing service to users from industry and research.

2. Mass Flow Measurement Setup

The existing tubing configuration of the KOTNAS-c_p measurement bypass was extended to contain a Krohne OPTIMASS 6000F-HT S80 Coriolis mass flow sensor. This sensor was found to be of sufficient accuracy and suitable to be operated at temperatures up to 400 °C. Other components installed in the bypass facility are limited to maximum 350 °C which may reduce the overall maximum operation temperature below 400°C. Its mass flow measurement range copes with typical operating parameters of parabolic trough collector test facilities or singe collector loops (subunit of solar fields). Figure 1 depicts the measurement uncertainty over nominal mass flow for the OPTIMASS 6000 - S 80 sensor series.



Mass Flow in kg/s	Uncertainty in %
0,167	0,750
2,453	0,100
32,500	0,100

Figure 1: Measurement uncertainty over nominal mass flow for Krohne OPTIMASS 6000 - S 80 series

The Coriolis senor connects directly between inlet and outlet of the existing bypass facility. The process and instrumentation diagram (P&ID) shows the newly installed connection and its components in Figure 2 in red colour:

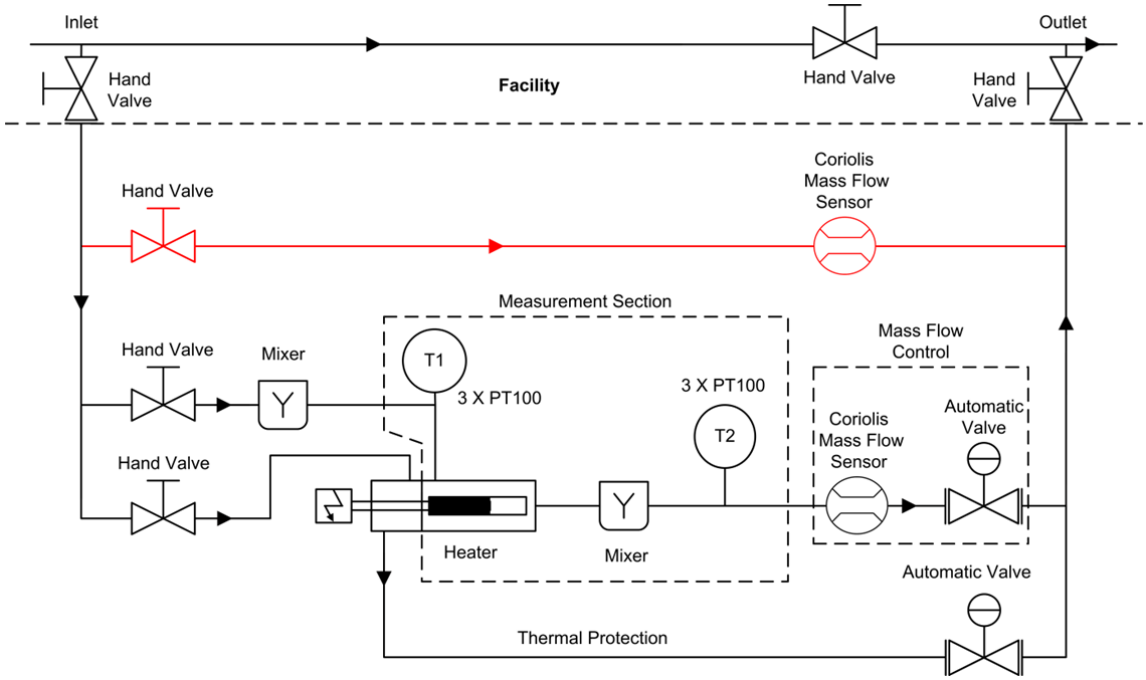


Figure 2: Process and instrumentation diagram of the KONTAS-c_p measurement bypass, Coriolis mass flow sensor for calibration and connecting tube section indicated in red

The following drawing shows the 3D model of the whole measurement bypass without thermal insulation:

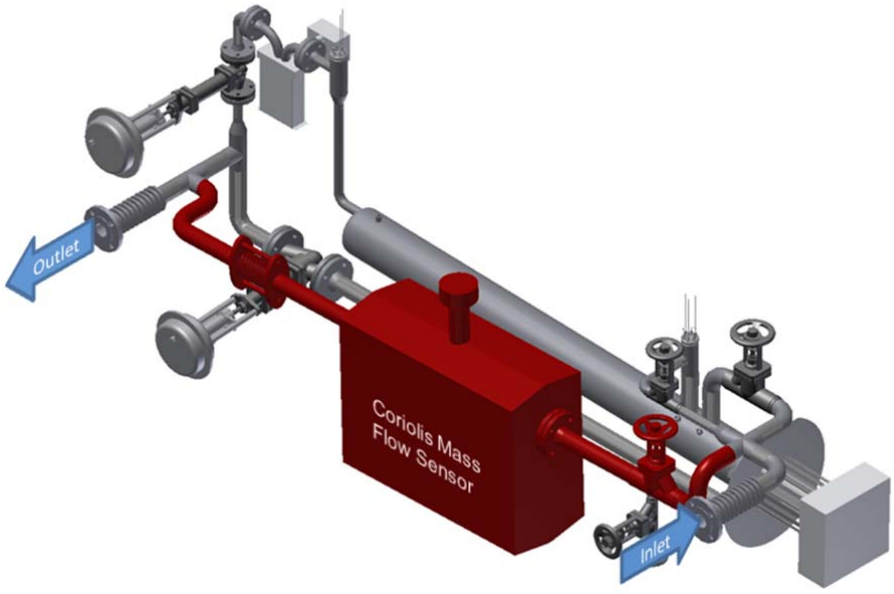


Figure 3: 3D view of the bypass facility without thermal insulation. New tube section and Coriolis sensor highlighted in red

For commissioning, the Coriolis sensor was operated using water at ambient temperatures. Figure 4 shows the flow chart of the water circuit (left) and a photograph of the setup (right).

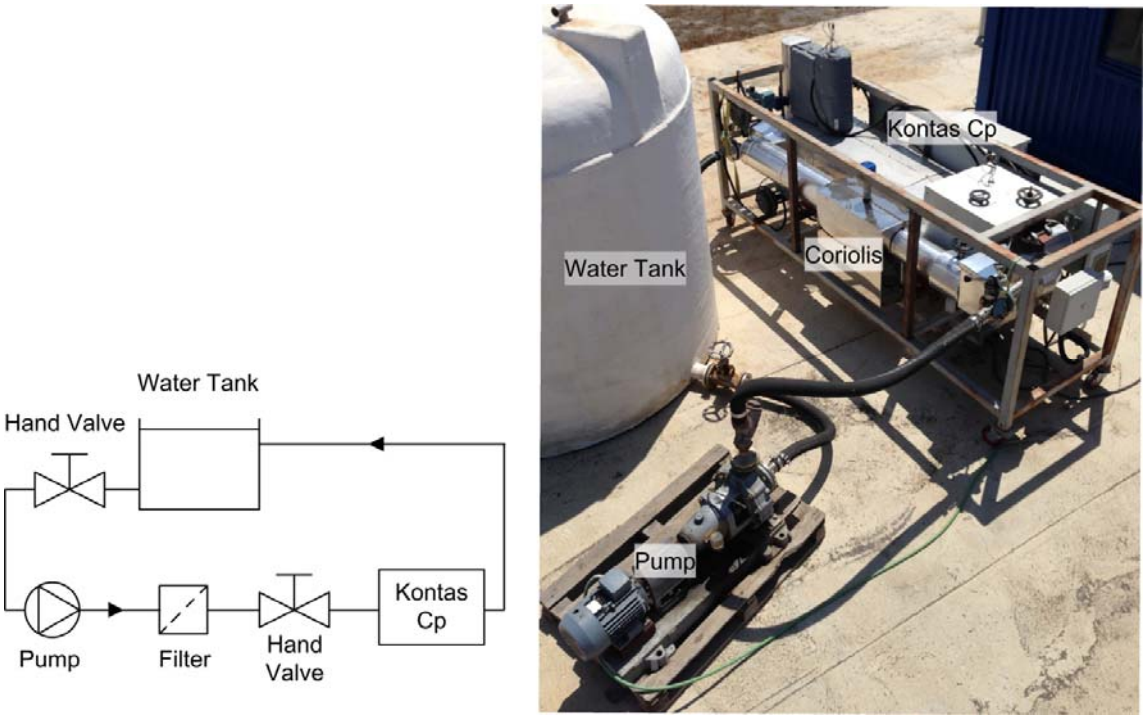


Figure 4: Water circuit with flow through measurement bypass, left: flow chart of the water circuit, right: photograph of the setup with Coriolis mass flow sensors installed

List of abbreviations and definitions

c_p	Specific heat capacity at constant pressure
CSP	Concentrating Solar Power
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
HTF	Heat Transfer Fluid
KONTAS	Konzentrator-Teststand Almería Spanien (Concentrator test facility Almería Spain)
KONTAS-c_p	Equipment for measuring the c_p of different HTFs as part of the Kontas project
PSA	Plataforma Solar de Almería (Facility for research in solar power plants near Almería)
PT100	Platinum resistance thermometer with resistance R = 100 Ohm
SFERA II	Solar Facilities for the European Research Area - Second Phase
Sylterm 800	Brand name for a silicone oil based HTF
Therminol VP1	Brand name for a silicone oil based HTF
u(x)	Uncertainty in the determining of x with 2σ confidence interval
WP 11	Work Package 11

List of publications

[Hilgert 2012] Christoph Hilgert, Gregor Bern und Marc Röger (2012) KONTAS-CP - Flow Through Calorimeter for Online Heat Capactiy Measurement of Thermal Oils in CSP Application. SolarPACES 2012, Marrakesch (Marokko).