ETEKINA
Thermal energy recovery

D2.6 – Common commissioning procedure (PU)

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WP 2, T 2.4

Authors: Bakartxo Egilegor, Matteo Venturelli, Fouad Al-Mansour, Marko Peckaj, Sulaiman Almahmoud, Lujean Ahmad and Hussam Jouhara.

Heat pipE TECHnologies for INdustrial Applications.

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Technical References

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

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Summary

To use the same acceptance procedure for the 3 use cases, a common commissioning procedure is defined to confirm the installations are ready for their evaluation.
The commissioning procedure considers the following aspects: the inspection of piping layout, the sensors and data acquisition operation, electric connection, hydraulic and thermal performance and the acceptance of Waste Heat Recovery System (WHRS) installation comparing design and real performance values.
Following the Scientific Coordinator's suggestion the acceptance criteria will be defined by the technician, the RTD and the industrial partners, case by case, when the installation was ready for the commissioning.
The commissioning procedure is described in this document (D2.4) and it will be used in WP4 for the 3 use cases installations commissioning.

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Introduction

1.1 Introduction

The aim of the commissioning procedure is to verify the installation is ready for its evaluation. In order to use the same procedure for the 3 different demo cases a common commissioning procedure has been defined.

This document describes the procedure to check the installation is ready for being evaluated. This procedure will be later used in WP4 for the 3 use cases installations commissioning.

The following aspects of the installation will be commissioned:

- Piping layout
- Sensor and Data Acquisition System (DAS) commissioning:
- Electric commissioning:
- Control commissioning:
- Hydraulic commissioning:
- Thermal commissioning:

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Commissioning procedure

Commissioning procedure will be done by the responsible of the installation of the industrial partner with the collaboration of the team partners if needed.

2.1 Prior to initial start up

2.1.1 Inspection of piping & components layout

A list of components of the WHRS will be elaborated linked with the PI& D diagram. The elements, their location and the piping sizes and piping layout will be checked by a visual inspection comparing them with the PI&D diagram description.
Any observed conditions not addressed by the PI&D drawing will be noted, notified and the installation will be modified.
The visual inspection of the piping layout should be repeated afterwards.

2.1.2 Air purging

In the demo cases where there are liquid streams loops, air purging procedure will be executed by recirculation of the fluid repeatedly until there is no air presence evidences in the circuits (unexpected noises, pressure fluctuations in manometers, flow anomaly fluctuations, etc.).
A visual inspection will be done to check the absence of leakages.

2.2 Sensor and Data Acquisition System (DAS) commissioning

Check the values of the sensors and identify if there are out of range values.
For the failure sensors verify their electrical signal outputs (for instance, V, mA,...) and the conversion to the measured physical units.
Verify and make a note of the temperature values of the inlet and outlet of the primary stream and of the secondary stream, ambient temperature and waste heat stream temperature.
Verify and make a note the primary and secondary streams flow rates or the equivalent sensor signal depending of the measure method (dynamic pressure or velocity values).
Verify and make a note natural gas and electricity consumptions of the heat sink processes and the BOP.
Check the coherence of the values and the time step of registered values. Verify sensors labels and their correct position in the registered data file.

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If there is more than one acquisition system, their time synchronization will be checked. If there are clock time differences they should be adjusted for a coherent and right data cross evaluation.

2.3 Electric commissioning

All the drivers will be checked if they operate as it is expected when they are electrically feed (pumps' and fans' flow direction), valves operation and safety relays. The variable speed actuators of the fans or pumps will also be verified.

2.4 Control commissioning

2.4.1 Operating modes testing: Bypass mode and Heat recovering mode

Two general operating modes will be defined:

- Bypass mode
- Heat recovering mode (HR mode)

The bypass mode operation is designed to allow the plant runs as it was previous to the WHRS installation whenever it is necessary (HPHE failures or maintenance operations).
The heat recovery mode refers to the operating mode of the WHRS designed under ETEKINA project to recover waste heat and to use it in the heat sink processes.
There will be a control switch or equivalent signal to change the operation mode from bypass mode to heat recovering mode and vice-versa.

Verify the valves' position and the state of the elements (fan, pumps,...), if they are operating or they are stopped, in both operating modes (Bypass/HRmode) activating the operation switch.

Verify the safety operating mode: in case of failure in the WHRS installation, the failure signal(s) will change the operating mode to Bypass mode.

The safety signals of HPHE will based on thermocouples.

Each demo case has its own specific performance characteristics (number of heat sink processes, temperature levels, operation strategies, etc.) and their control operation commissioning will be done.

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2.5 Hydraulic commissioning

2.5.1 HPHE hydraulic specifications

Put the WHRS in the heat recovery operating mode (see chapter 2.4.1) and check if the expected drivers (fans/pumps) are active and the valves in their correct position.
In case there are variable speed actuators verify that fans/pumps are running at their nominal speed and adjust the speed to obtain the design values.
Compare the primary and secondary streams' flow rates and the pressure drop values across HPHE with the design values.
The design flow rate and pressure drop couple represents a point in the pressure versus flow rate diagram. The obtained flow rate-pressure drop pairing point will be in one of the four different relative positions shown in the following graph.
For each stream at what point is expected to work and currently in which point is working will be checked.
Following the Scientific Coordinator's suggestion, the hydraulic acceptance criteria will be defined by the technician, the RTD and the industrial partners, case by case, when the installation is ready for the commissioning.

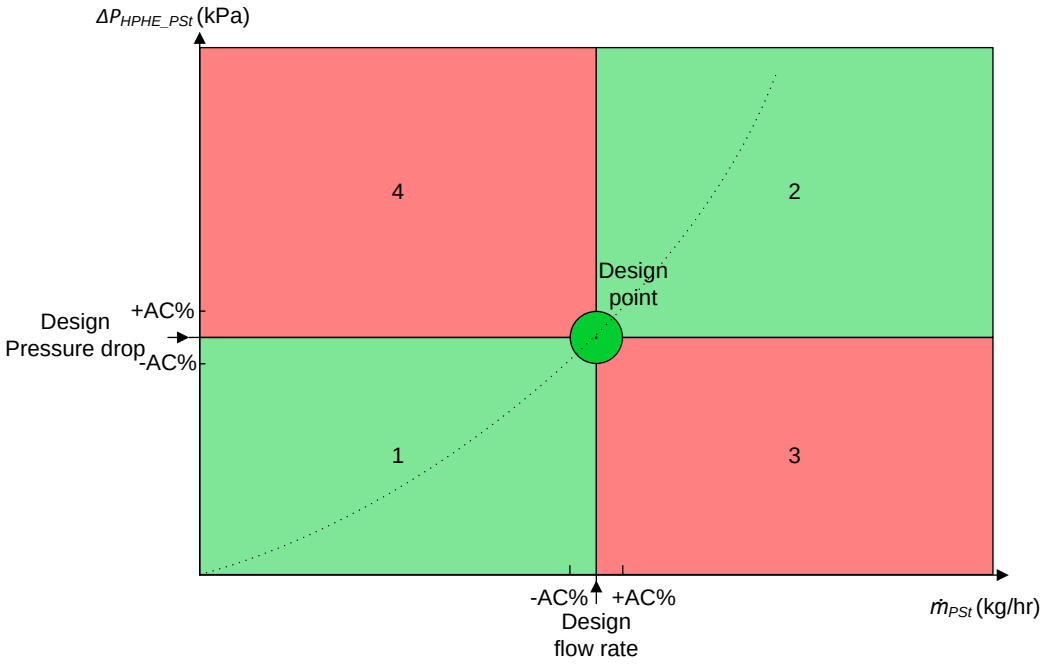

Figure 1- Pressure drop versus flow rate relative 4 positions compared to the design point ±AC, Acceptance Criteria.

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If the obtained flow rate and pressure drop values are within the hydraulic acceptance criteria of the design flow rate and pressure drop values, the HPHE is responding hydraulically as expected and the hydraulic acceptance will be completed.
Otherwise the flow rate-pressure drop pairing will be in one of the four different relative positions shown in the following graph.

If the measure pairing is within the numbered 1 quadrant, the flow rate and pressure drop, both are lower than the design values. Try to increase the pump or fan speed to reach the design value.

If the measure pairing is within the numbered 2 quadrant, the flow rate and pressure drop, both are higher than the design values. Try to reduce the pump or fan speed to reach the design value.

If the measure pairing is within the numbered 3 quadrant, the flow rate is higher than the design value; however the pressure drop is lower than the design value. If the measure pairing is within the numbered 4 quadrant, the flow rate is lower than design value and the pressure drop is higher than the design value. In both cases, the HPHE component requires supervision of the technology supplier.

2.5.2 HPHE hydraulic specifications of demo case 1, 2 and 3

Each HPHE has its own design specifications designed according to each demo case requirements. The hydraulic commissioning will consist in testing and checking the real flow rate and pressure drop coupling values and comparing them with the design values. Depending of the results and according the acceptance criteria defined by the technician, the RTD and the industrial partners when the installation was ready for the commissioning, the hydraulic performance will be accepted or not. The following acceptance table is provided to be filled by the responsible of the installation of the industrial partner of each demo.

Table 1- Common Hydraulic acceptance table

Comissioning Aspect	Desing values		Measured values		Relative Position	Acceptance	Date	Signature
	ΔP (kPa)	$\dot{m}$ (kg/hr)	ΔP (kPa)	$\dot{m}$ (kg/hr)				
Primary Stream					1,2,3 or 4	YES/NO		
Secondary Stream					1,2,3 or 4	YES/NO		

Apart from the mentioned hydraulic specification, depending of the application additional specification may have been required for the HPHE design. For example, absolute pressure maximum limits, minimum limits, etc. In case there are additional specified hydraulic

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variables they should be verified and included in the corresponding demo case specific hydraulic commissioning procedure.

2.6 Thermal performance testing

2.6.1 HPHE Thermal specifications

Put the WHRS in the heat recovery operating mode (see chapter 2.4.1) and check if the expected drivers (fans/pumps) are active and the valves in their correct position.
The HPHEs are designed based on the primary stream flow rate, its inlet temperature and the secondary stream(s) flow rate(s) and its (their) inlet temperature(s). Based on the design specifications, there is a design performance thermal power value for each demo case that will be used as a reference for thermal commissioning.
However, not only the thermal power will be checked, the temperature inlet and outlets and flow rates will be evaluated and compared to the design specified values.
For thermal commissioning a stable performance conditions will have to establish. Once the temperature and flow rates reach a stable condition the values will be compared with the design values.

2.7 Criteria for thermal acceptance

Once the WHRS reaches a stable performance, the values will be compared with the design points. If they are within the acceptance criteria values the thermal commissioning will be finished.

Table 2- Common thermal acceptance table

Commissioning Aspect	units	Design values	Measured Calculated values	criteria	Acceptance	Date	Signature
T_{PSt_In}	°C				NO		
T_{PSt_Out}	°C				NO		
T_{SSt_In}	°C				NO		
T_{SSt_Out}	°C				NO		
$\dot{m}_{PSt}$	kg/h				NO		
$\dot{m}_{SSt}$	kg/h				NO		
CP_{PSt}	KJ/kgºC				NO		
CP_{SSt}	KJ/kg-ºC				NO		
$\dot{Q}_{PSt}$	kW				NO		
$\dot{Q}S_{St}$	kW				NO		

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In case the inlet temperatures and the flow rates do not comply with the acceptance criteria the installation should be reviewed and adjusted. In case the outlet temperatures and transferred thermal power do not comply with the acceptance criteria the HPHE component will require a supervision of the technology supplier.

Following the Scientific Coordinator's suggestion, the thermal acceptance criteria will be defined by the technician, the RTD and the industrial partners, case by case, when the installation was ready for the commissioning.

2.8 Acceptance results

The acceptance testing results will be collected in a template (Annex I) by the responsible of the installation of the industrial partner. The collaboration of the rest team partners would be provided in case is necessary.
The WHRS installation will be revised as many times as required until all the commissioning aspects will be within the acceptance criteria.
From that moment the commissioning procedure will be completed, and the commissioning acceptance template is signed by the responsible of the installation, the evaluation period could start.

Conclusion

The commissioning procedure has been defined to be used in WP4 to approach the demo cases to a safe and reliable performance conditions with the aim of registering valuable performance data with minor disturbances in the production process.

Following the Scientific Coordinator's suggestion, the acceptance criteria will be defined by the technician, the RTD and the industrial partners, case by case, when the installation was ready for the commissioning.

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References

[1] Standard Commissioning for Chillers;
http://www.seattle.gov/light/conserve/business/bdgcoma/bca2.pdf

[2] Testing and commissioning procedure for Air-Conditioning, Refrigeration, ventilation and Central Monitoring & Control System Installation In Government Buildings of The Hong Kong Special Administrative Region. 2007 Edition.
https://www.archsd.gov.hk/media/11356/e177.pdf

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ANNEX 1: Acceptance Templates

Comissioning Aspect	Criteria/value	Acceptance	Notes (use method, incidences,next steps, …)	nº of revision	Date	Signature
Piping & components layout	Visual inspection, no visual leaks	NO				
Air purging	No unusual noise or vibration, pressure and flow rate signals regularity	NO				
Sensor and Data Acquisition System (DAS)	Verify the sensors values (out-of range values) , frequency of registration, different sources synchronization, sensor's labels and registered data file format	NO				
T_{IA}	°C	NO				
T_{PSt_In}	°C	NO				
T_{PSt_Out}	°C	NO				
T_{SSt_In}	°C	NO				
T_{SSt_Out}	°C	NO				
$\dot{m}_{PSt}$ or equivalent variable (dynamic pressure, velocity,…)	kg/s, m/s, Pa	NO				
$\dot{m}_{SSt}$ or equivalent variable (dynamic pressure, velocity,…)	kg/s, m/s, Pa	NO				
heat sink process natural gas consumption	m3/h, kW and t,KWh…	NO				
WHRS electricity consumption	kW and t, kWh	NO				
Electric commissioning	verify all drivers (fans, pumps, valves, safety relays,…) operation when they are electrically feed	NO				
	pumps' and fans' flow direction	NO				
	variable speed actuators	NO				
Control commissioning	Verify the control switch (Bypass/HRmode)	NO				
	Verify the safety operating mode	NO				
Hydraulic commissioning	in the HRmode, Compare Primary stream flow rate and pressure drop pair values with the flow rate and pressure drop desing values	NO				
	in the HRmode, Compare Secondary stream flow rate and pressure drop pair values with the flow rate and pressure drop design values	NO				
Hydraulic commissioning DC1/DC2/DC3	See *Hydraulic Com DCx* page					
Thermal commissioning DC1/DC2/DC4	See *Thermal Com DCx* page	NO				

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Comissioning Aspect	Desing values		Measures values		Relative Position	Acceptance	Date	Signature
	ΔP (kPa)	$\dot{m}$ (kg/hr)	ΔP (kPa)	$\dot{m}$ (kg/hr)				
DCx Primary Stream					1,2,3 or 4	NO		
DCx Secondary Stream					1,2,3 or 4	NO		

Comissioning Aspect	units	Desing values	Measures/calculated values	criteria	Acceptance	Date	Signature
T_{PSt_In}	°C				NO		
T_{PSt_Out}	°C				NO		
T_{SSt_In}	°C				NO		
T_{SSt_Out}	°C				NO		
$\dot{m}_{PSt}$	kg/h				NO		
$\dot{m}_{SSt}$	kg/h				NO		
CP_{PSt}	KJ/kgºC				NO		
CP_{SSt}	KJ/kg-ºC				NO		
$\dot{Q}_{PSt}$	kW				NO		
$\dot{Q}S_{St}$	kW				NO		

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