# Smart Ways for In-situ Totally Integrated and Continuous Multisource Generation of Hydrogen

# D6.2: Report on the functional and operational check of the SWITCH system

***WP6***

***June 2024***

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No **875148**. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research

Co-funded by the European Union

## Technical References

| | |
|---|---|
| Project Acronym | SWITCH |
| Project Title | Smart Ways for In-situ Totally Integrated and Continuous Multisource Generation of Hydrogen |
| Project Coordinator | Matteo Testi - FBK<br>testi@fbk.eu |
| Project Duration | January 1, 2020 - Mar 31, 2024 (51 Months) |

| | |
|---|---|
| Deliverable No. | D6.2 |
| Dissemination Level | PU[1] |
| Work Package | WP 6 – System Construction and Testing |
| Task | T 6.3 – RESULT ANALYSIS |
| Lead beneficiary | 1 (FBK) |
| Contributing beneficiary(ies) | 2 (SE), 4 (HYGEAR) |
| Due date of deliverable | 31 January 2024 |
| Actual submission date | 28 June 2024 |

[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).

## Versions

| Revision Version | Date | Changes | Changes made by Partner |
|---|---|---|---|
| 0.1 | 31 March 2024 | Preparation of template | Elena Crespi, FBK |
| 0.2 | 19 June 2024 | Inclusion of graphs and Annex | Ilaria Mirabelli, HyGEAR |
| 0.3 | 26 June 2024 | Revision of SolydEra, inclusion of graphs, information and information on preliminary tests (integration and functional tests) | Florian Deneve / Stefan Diethelm, SolydEra |
| 0.4 | 28 June 2024 | Revision of Elena Crespi and submission | Elena Crespi, FBK |

# Table of Content

1 Introduction ........ 6
2 Preliminary tests ........ 7
2.1 Integration test ........ 7
2.1.1 I/O and communication check ........ 8
2.1.2 Safety and Watchdog verification ........ 8
2.1.3 Flow Control System verification ........ 8
2.2 Functional tests ........ 9
2.2.1 Startup / Shutdown test ........ 9
2.2.2 Heat-Up / Cool-Down tests ........ 9
2.2.3 Condenser/Separator validation ........ 10
2.2.4 Coupling / Decoupling ........ 11
3 Plant commissioning tests ........ 16
4 Conclusions ........ 18
Annex I ........ 19

# List of Acronyms

| | |
|---|---|
| BoP | Balance of Plant |
| CH2P | Co-generates Hydrogen, Heat and Electricity |
| EL | Electrolysis |
| ESD | Emergency Shut-Down |
| FC | Fuel Cell |
| HSB | Hot Stand-By |
| HX | Heat exchanger |
| HYG | HyGEAR |
| I/O | Input/Output |
| LSM | Large Stack Module |
| MFC | Mass-Flow Controller |
| MFM | Mass-Flow Meter |
| NG | Natural Gas |
| NLPM | Normal Liters Per Minute |
| NSR | Non-Safety-Related |
| PDE | Differential pressure sensor |
| PE | Pressure element |
| PID | Proportional–integral–derivative controller |
| PLC | Programmable Logic Controller |
| PSA | Pressure-Swing Adsorption |
| rSOC | reversible Solid Oxide Cell |
| SAT | Site Acceptance Test |
| S/C | Steam-to-Carbon ratio |
| SOEC | Solid Oxide Electrolysis Cell |
| SOFC | SolidOxide Fuel Cell |
| SP | SolidPower, now named SolydEra |
| SR | Safety-Related |
| WKO | Water Knock-Out |

# 1 Introduction

The SWITCH project aims to develop an in-situ fully integrated and continuous multisource hydrogen production system, based on solid oxide cell technology. It focuses on the development of a system able to both efficiently convert variable electricity from renewables and steam into green hydrogen in electrolysis mode (SOEC), and to operate in fuel cell (SOFC) mode to enable the use of other sources (e.g., methane, bio-methane) to match a variable electricity production with continuous and guaranteed production of hydrogen.

The system prototype, comprising a reversible Solid Oxide Cell (rSOC) module supported by an advanced fuel processing unit able to manage steam generation and methane reforming reactions, and a purification unit to guarantee highly pure hydrogen, has been designed and realized. The realization of the system, capable of producing up to 100 kg/day of $H_2$ and having a maximum power output of 50 kWel, is described in Deliverable D6.1.

This Deliverable describes the functional and operational check of the SWITCH system, including preliminary checks with a dummy stack to tune the coupling/decoupling procedure of the compressors and the system heating procedure, the Aactory Acceptance Test (SAT), and I/O checks.

# 2 Preliminary tests

This first testing phase includes a series of tests meant to check the correct functional and operational behaviour of some components, the programmed state machine, the procedures (start up, coupling/decoupling, cooldown, ...) and perform the tuning of the control parameters (PID values).

Preliminary tests are firstly done on the module equipped with a dummy Large Stack Module (LSM) and then, once everything has been verified, on the module with a “real” LSM. The dummy LSM test step is required to validate the integrated system while preserving the integrity of the real LSM.

The main goals of these tests are:

- To validate the integration and the assembly of the overall system by performing unit/individual testing of subsystems (communication, gas lines, burner ignition, gas routing, safety verification, ...);
- To perform a functional validation, with a strong focus on tuning and validation of two features of the system:
    - The procedure to heat up the system.
    - The procedures for coupling and decoupling the two compressors (for hydrogen and syngas).

## 2.1 Integration test

An integration test was carried out to check functionality of the three different parts of automation logic, namely:

- HYG-NSR-PLC, which is the PLC on HyGEAR side, taking care of all the instruments and actuators for the flow control, the downstream processing units, the compressors and all the utilities and accessories around the modules.
- SP-NSR-PLC, which is the PLC on SolydEra side, responsible for the automation on the module.
- SP-SR-PLC, which is the Safety PLC on SolydEra side, responsible for the safety of the module (gas, burner and overall module).

Even though the modules are independent on paper (besides safety interlock), both the HYG-NSR-PLC and the SP-NSR-PLC are intricated on the Flow Control subsystem where data is exchanged over Modbus TCP communication (setpoints, present values,...).

The integration test was performed once all the mechanical and electrical activities were completed by both SolydEra and HyGEAR. The testing comprised:

- I/O and communication check
- Watchdog and Safety verification
- Flow Control System verification

### 2.1.1 I/O and communication check

An I/O test was thoroughly performed by SolydEra on both modules to ensure no sensors were broken during shipping or installation. This procedure uses a standard validation sheet to validate the overall I/O, from end to end. This test allowed to solve some wiring and scaling issue.

The communication check for the Modbus TCP confirmed that the address mapping and the low-level commands was properly setup (which was not as straight forward between 2 different PLC brands). It also allowed to check the heart-beat variable exchange (for the Watchdog monitoring).

### 2.1.2 Safety and Watchdog verification

*Safety check*

Prior to flow control validation with flammable gases or critical hardware, the full safety check was performed by SolydEra and HyGEAR, consisting of:

- ESD (Emergency Shut-Down) interlock chain: if one of the ESD is tripped on either side (HYG-NSR-PLC or SP-SR-PLC), each side's ESD shall be tripped.
- ESD action: make sure that on both sides the proper safety actions take place (de-energizing actuators to bring them in their default positions like valves, relays, blowers, ...).
- ESD triggers: check any limits that should trigger the ESD on either side.

*Watchdog check*

On SolydEra's side, an additional verification layer is performed by what is called the Watchdog. It is independent from the safety layer but performs the same verification at different levels and other more complex verifications. The goal of the Watchdog is to guarantee module integrity irrespective its performance. It monitors the module at all times, checks for limits, triggers alarms if needed and alerts operator via email/sms gateway.

The watchdog was thoroughly checked to ensure all operators were alerted in case of abnormal behaviour.

### 2.1.3 Flow Control System verification

Most of the verifications have been done at low temperature (cold) when possible. Since some safety features prevent the use of flammable gases at low temperature, part of the flow control system was tested after the first heat-up, when Hot-Standby temperature had been reached, according to the test protocol detailed below.

The Flow Control System final validation protocol is highlighted below:

- This test takes place when the system is hot (after complete heat-up).
- During this testing phase the pre-reformers in the hot BoP modules are fed with NG and steam (reforming reaction occurs in the reformers), the burners provide the heat to sustain the reaction. The reformate gas streams, after cooling and steam condensation, are vented or sent to the burner.
- The remaining gas train lines are tested: $H_2$ high flow, $NG_{reform}$ and steam.

- The test of $H_2$ high flow consists of increasing $H_2$ high flow up to 70 NLPM (confirming the Mass Flow Controller (MFC) or valves, and the Mass Flow Meter (MFM) control parameters and capabilities).
- To test the $NG_{reform}$ valves and control parameters, steam is first injected into the system, up to 150 or 200 NLPM. Once the flow is established, $NG_{reform}$ feed is tested, not exceeding 25 NLPM. During this test, a dilution of 10% of $H_2$ is fed into the system to ensure protection of coating within the hot BoP.

This test also stresses the condenser/separator and validates the operation of the cooling and water separation.

## 2.2 Functional tests

The functional tests described in the following assumes that all the individual sub-systems have been tested and are operational.

### 2.2.1 Startup / Shutdown test

This test focuses on making sure that it is possible to navigate within the state machine from INIT to IDLE, from IDLE to READY and back:

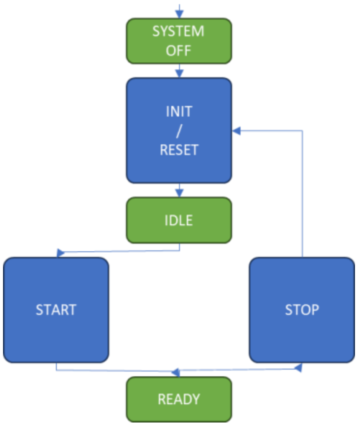


*Figure 2.1 - Start/Stop state machine extract: From SYSTEM OFF to READY*

Once in READY, the module is considered safe as it has been pressurized and flushed, and it is ready for heat up. Therefore, the following function are considered verified and operational:

- Pressure management
- Gas safety
- Flow control for air process, nitrogen, air auxiliary

### 2.2.2 Heat-Up / Cool-Down tests

When the SWITCH system is initialized for the SOFC or for the SOEC operating mode, the start-up procedure requires a controlled heating up of the system. Indeed, to safely reach the operating temperature, the system needs to be heated up by steps and several parameters need to be controlled during the process.

The heating up procedure to reach FC and EL operating mode includes different phases.

The steps to reach FC operation modes include:

- Burner activation (NG make up, air at the cathode side, forming gas at the anode side, fixed ramp of temperature);
- Steam flow activation (steam to avoid soot, optional electrical heater to support the steamer, water pump);
- NG flow activation (NG flow to the reformer, high S/C ratio);
- S/C ratio adjustment (adjust the flows to be suitable for the next selected state: FC hot standby or production).

The steps to reach electrolysis operation modes include:

- Steam flow activation at the cathode side
- Air flow activation at the anode side
- Enabling the Electrical heaters

The preliminary tests with the dummy stacks are performed to validate the procedure while assuring that the real LSM is not damaged.

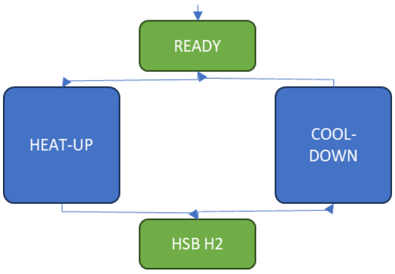


*Figure 2.2 - Heat-Up/Cool-Down state machine extract: from READY to HSB H2*

Figure 2.3 shows the temperature of the dummy LSM during the heat-up phase of system A. It took around 30 hours to get the system to the HSB H2 state, which is longer than nominal heat-up due to alarms and adjustments to be done on the system along the heat-up. 6 hours later, the LSM was roughly thermally stable. The system heat-up was done under $H_2/N_2$ mixture up to Hot-Standby temperature (no switch to Steam/$CH_4$ was present).


*Figure 2.3 - System A heat-up, focus on LSM temperature.*

### 2.2.3 Condenser/Separator validation

Condenser/separator validation test is performed once the system is hot, that is once HSB H2 is reached to guarantee a homogenous and stable temperature within the module. The goal is to confirm that all the steam has condensed and that it has been removed from the stream, before sending the steam to the compressor and PSA section. To focus on this section and not to impact the rest of the system, the module is decoupled, and the stream is vented.

Since this test is done with the dummy LSM, the stream is defined to mimic the stream that will be present with the real LSM, for what is interesting for the test. The most stressful operating conditions for the condenser/separator are considered: 250 NLPM (~12kg/h) of steam and 75 NLPM of $H_2$ are injected from the gas train into the system (ramping the flow within less than 5 minutes). The stream flows with no reaction into the module and it is left over to the condenser/separator to be processed.

### 2.2.4 Coupling / Decoupling

The system BoP includes two compressors, to increase the pressure of the hydrogen and of the syngas fed to the purification units in SOEC and SOFC mode, respectively. Thus, when switching from hot-standby (HSB) to SOFC or to SOEC operating mode and vice versa, a procedure is required to decouple the active compressor and couple the other one, while keeping the pressure under control.

When not in production modes, the modules are independent from the post-processing section. During this phase, modules are considered decoupled (from the downstream section). The stream can either be vented or sent back to the afterburner. The modules can be operated while the downstream section is turned off.

The so-called Coupling Sequence operates the system so that the production stream is sent to the downstream units for post-processing. The Decoupling Sequence does the opposite by isolating the modules' stream from the downstream section.

The coupling/decoupling is performed by a set of valves that are also responsible for the modules' backpressure control: one "decoupling" valve for the module return (burner or vent) and one "coupling" valve for the post-processing, the modules being independent from one another with its own set of valves. The control logic that has been implemented leverages on the experience from the CH2P project. It relies on one valve to control the pressure, while the other one follows a ramp down curve.

The post-processing section can be summarized as a buffer vessel, a first compression stage with a syngas compressor and a $H_2$ compressor (to accommodate stream pressure to PSA's nominal operating conditions), and the purification units (PSA).

The preliminary tests performed with the dummy stack allowed to check the correct operation of the compressor coupling/decoupling procedure.

The coupling/decoupling procedures were tested following this test plan:

*Cold coupling/decoupling (no compressors)*

A first test is performed at low temperature through the buffer vessel's vent with the dummy LSM. No compressors are involved. A stream of $N_2$ and then $H_2$ (mimicking production levels) is sent to the buffer vessel and is then vented. The decoupling can be done either towards the modules' vent or after burner (testing different back pressure conditions and validating the robustness of the PIDs). This step allows to validate the back pressure control while coupling/decoupling.

### *Hot coupling/decoupling (no compressors)*

A second test is performed following the same protocol as for the first test, but at high temperature (after completing the heat-up). The stream used here is a mix of steam and $H_2$ sent from the gas train through the BoP, the dummy LSM (no conversion occurs), the condenser, the water separator, the coupling valve and the buffer vessel.

Figure 2.4 show the overall coupling/decoupling sequences, while Figure 2.5 and Figure 2.6 zooms on the coupling and decoupling phase, respectively. The main parameters to observe are the position of the decoupling valve (light blue line), the position go the coupling valve (purple line), and the LSM differential pressure (orange and red lines). The figures show that the coupling is done in around 10s. The LSM delta pressure is affected by the coupling sequence with a small pressure drop and overshoot. This can be explained as there is no back pressure within the buffer vessel (connected to the atmosphere with the vent valve).

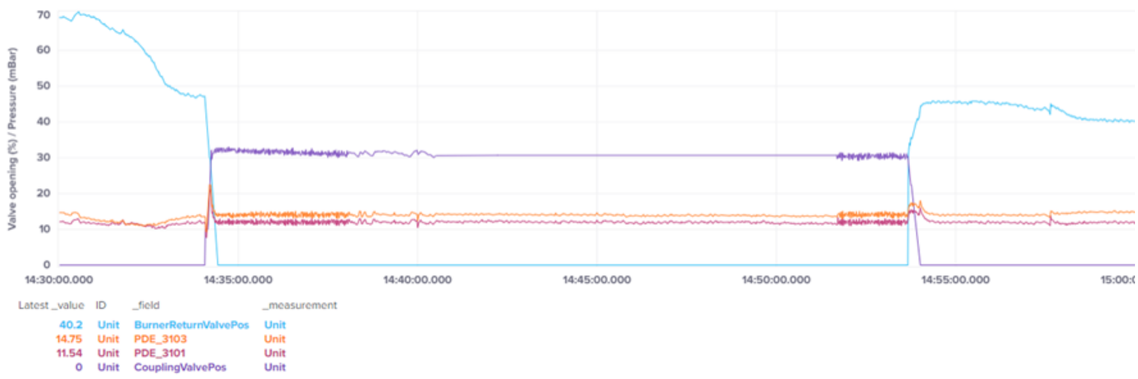


*Figure 2.4 - Coupling/Decoupling sequences. Coupling valve in purple. Decoupling valve in blue. LSM inlet delta pressure in red, outlet in orange.*

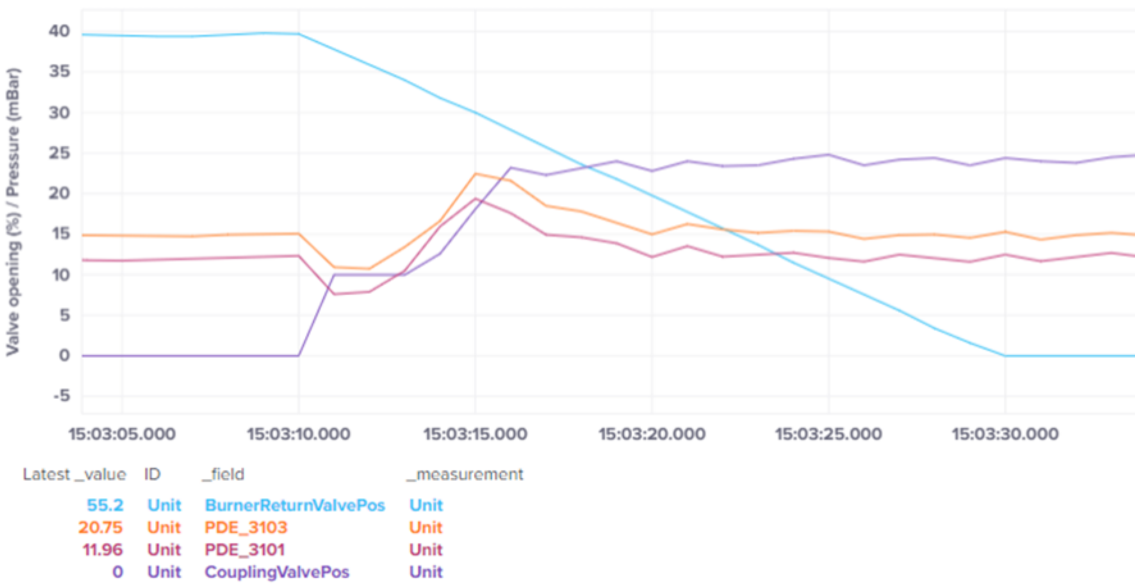


*Figure 2.5 – Zoom on the coupling sequence*

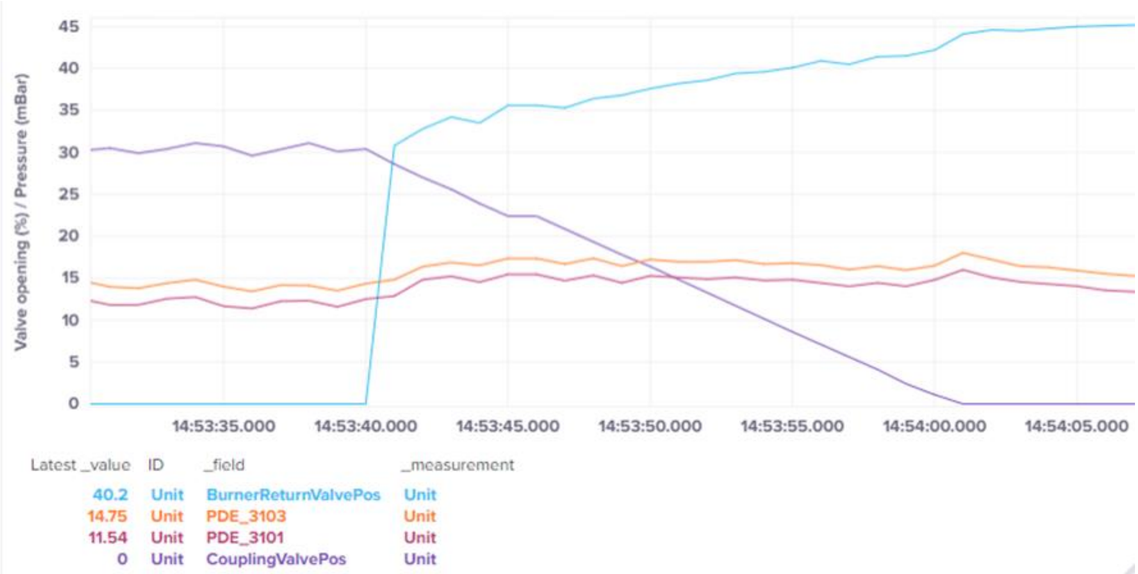


*Figure 2.6 – Zoom on the decoupling sequence.*

### *Hot Coupling / Decoupling (with syngas compressors)*

The syngas compressor start-up procedure was checked with hot coupling/decoupling tests including the syngas compressors. The buffer vessel pressure was controlled at 5 mbar.

Figure 2.7 shows the coupling/decoupling sequence with the syngas compressor. The coupling and decoupling procedure is tested twice. A first coupling of the compressor is done around 9.30, followed by compressor decoupling around 11.00, to tune the procedure. The coupling is tested again around 13.00, followed by decoupling around 15.00. In the coupling phase, the decoupling valve (purple line) closes while the coupling valve (green line) and the compressor recycling valve (light blue line) open. The opposite happens in the decoupling phase. Some overshoots are measured during the first test, but they are not present anymore after tuning. The compressor discharge pressure (black line) smoothly increases from the minimum to the setpoint value during coupling, reaching a stable value. A smooth variation is measured also in the decoupling phase. Finally, after tuning the procedure, a good control of the LSM differential pressure (pink line) has been demonstrated.

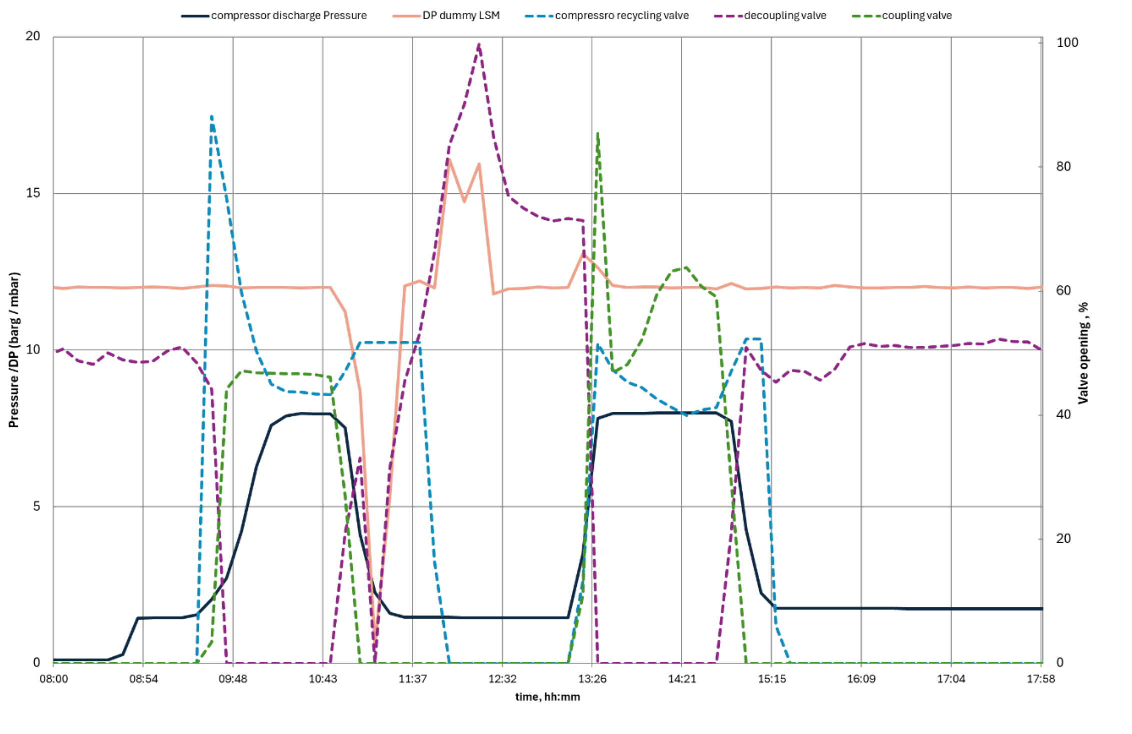


*Figure 2.7 - Testing of coupling/decoupling procedures with syngas compressor running: pressure and valve opening profiles*

### *Hot Coupling / Decoupling (with $H_2$ compressors)*

The coupling procedure with the $H_2$ compressors running has been tested first with the dummy LSM (System A) then with the real LSM (System B).

Figure 2.8 shows the coupling/decoupling sequence with the hydrogen compressor. The coupling procedure is done in a little less than 25s. Small variation in the compressor discharge pressure (black line) are measured when the coupling phase is started and negligible fluctuation of the dummy LSM differential pressure are observed. Overall, pressure disturbance due to the coupling is acceptable. The differential pressure setpoint is about 12 mbar in this test. The setpoint has lately been increased to 15 mbar to stay within the nominal window (from 10 to 20mbar).

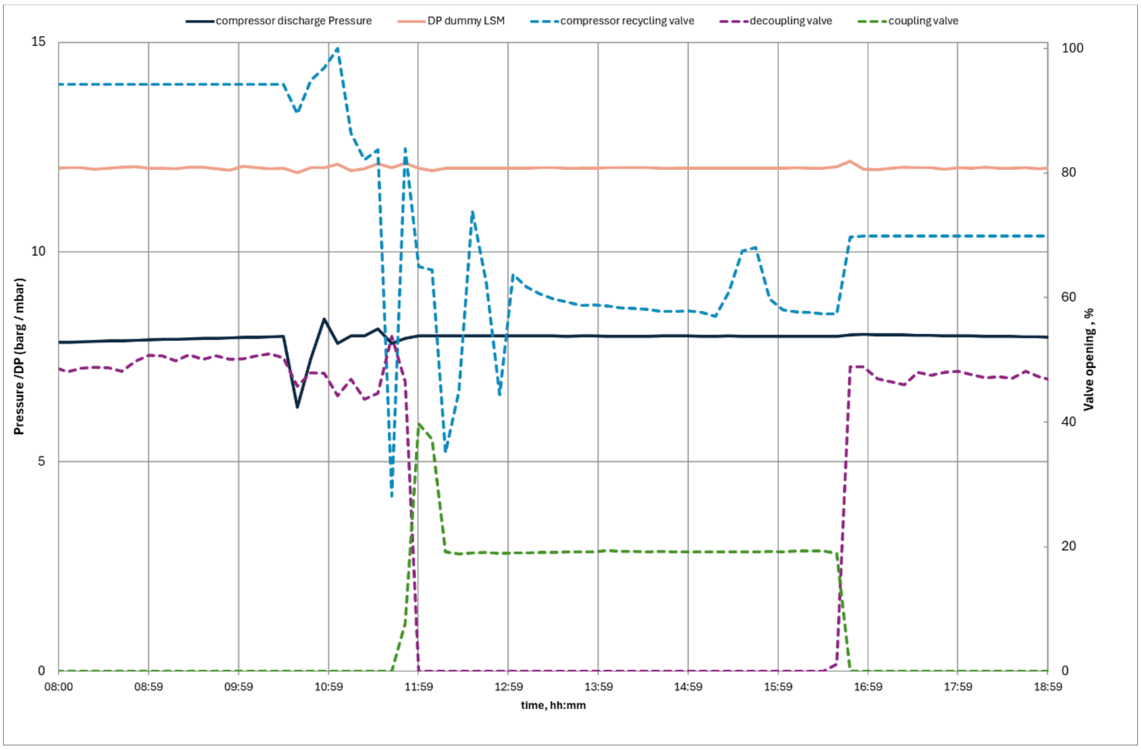


*Figure 2.8 - Testing of coupling/decoupling procedures with H2 compressor running: pressure and valve opening profiles*

Figure 2.9 shows the flowrates recorded for the real LSM while entering in electrolysis mode, when the coupling procedure occur. Prior to coupling, the HSB $N_2$+$H_2$ mixture is replaced by a mixture of steam and $H_2$ (the N2 flowrate decreases, while the H2 and flowrate increase). After the coupling, the module is ramped up, thus steam is increased. In this phase, the measured flow rates are not the nominal ones' (they have been adjusted later for the standard procedure). The coupling procedure follows the start-up of the compressor where the pressure in the buffer vessel is built up to 400 mbar and then lowered to the pressure setpoint of 5 mbar, accommodating nominal pressure for the stream to flow from the module.

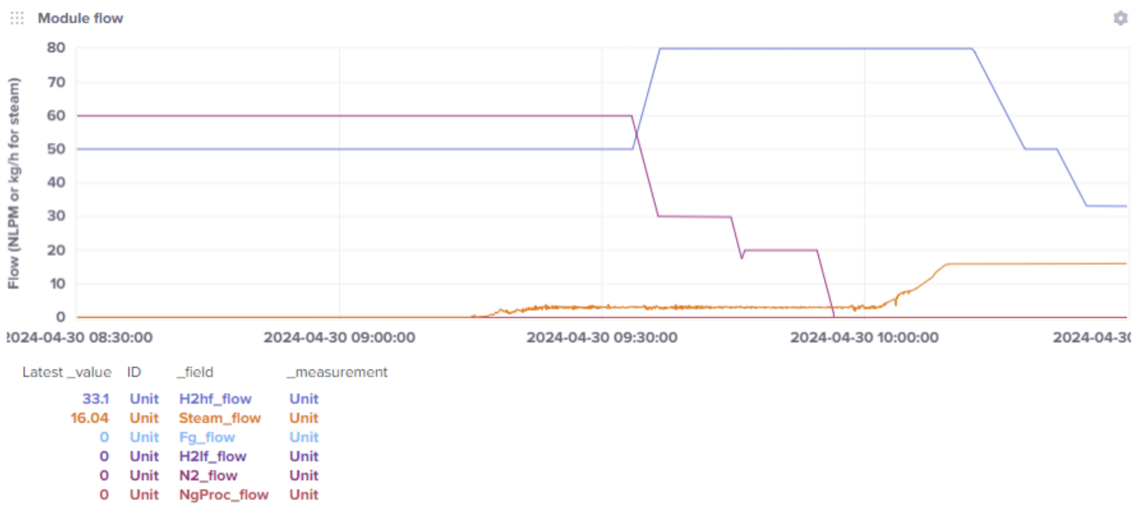


*Figure 2.9 - Hot coupling with H2 compressors. Module flow rate.*

# 3 Plant commissioning tests

Following the preliminary validation of the compressor coupling/decoupling procedure and of the heating-up procedure performed with a dummy stack, the real LSM was installed within the SWITCH prototype system and the main functional and operational check tests were performed at HyGEAR site.

A consistent part of the tests consists in I/O checks. Indeed, considering only the system cold BoP, more than 400 I/O signals are acquired and processed to guarantee the correct, effective and safe operation of the SWITCH prototype system. For each of these signals, the I/O check has been successfully performed. A partial list of all the I/O checked signals has been reported In Annex I.

As an example of functionality test of the main components, the operation of the WKO's drain is shown in Figure 3.1.

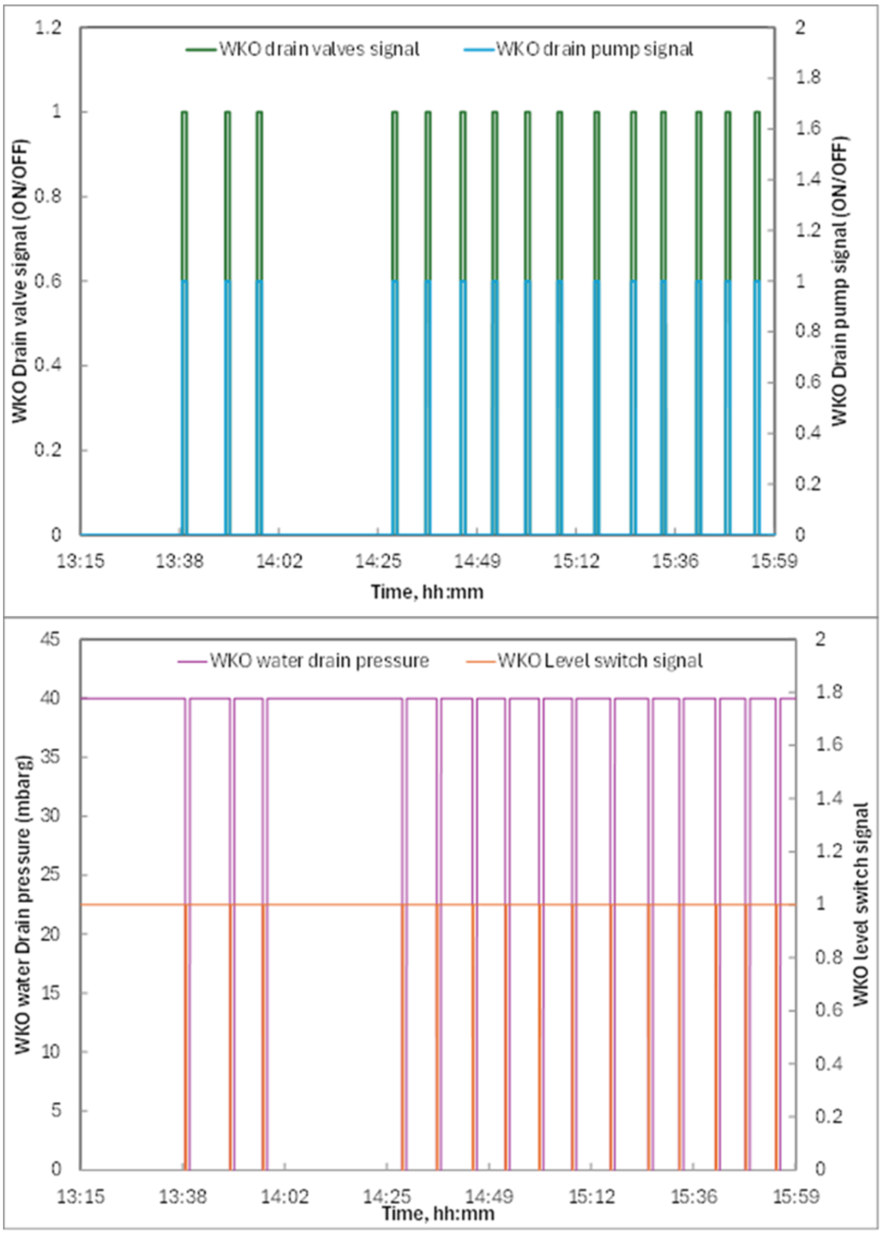


*Figure 3.1 - Check of the WKO functionality: profiles of the signals during operation of the WKO level switch, drain valves and water drain pump.*

The SAT was performed at HyGEAR site. Thanks to the preliminary tests, the main features of the systems were previosly validated. The SAT included the final tuning of the heating up procedure and the compressors coupling/decoupling. Overall, the SAT has ensured that the prototype meets the specified requirements, design criteria, and functionality defined for the SWITCH system.

As an example, Figure 3.2 illustrate the heat-up for System B (with real LSM). The optimization phase allowed to tune the heating-up procedure, being able to complete the heat-up in less than 21.5 hours. The LSM temperature became stable in 24 hours, even though some alarms were faced.

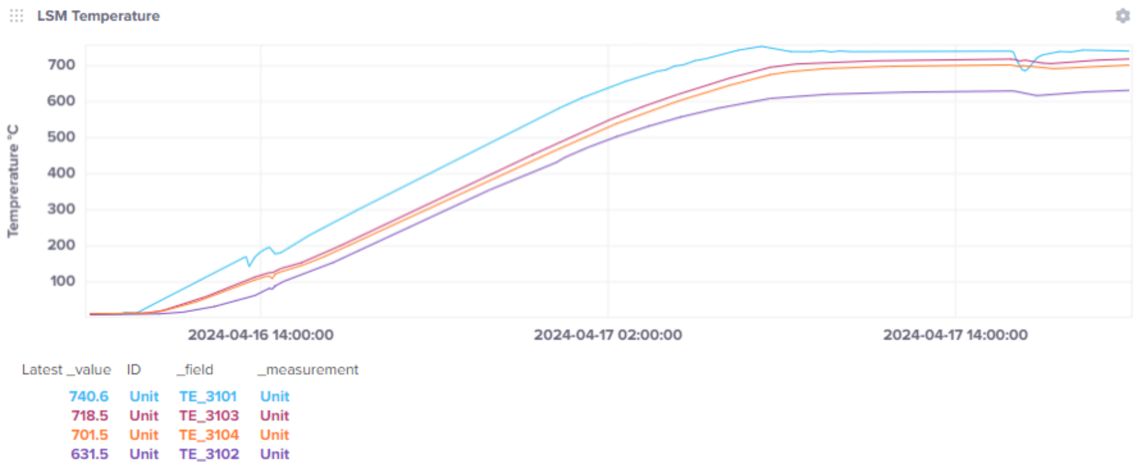


*Figure 3.2 - System B heat-up, focus on LSM temperature*

# 4 Conclusions

The functional and operational check of the SWITCH prototype system has been performed.

The preliminary check, firstly performed with a dummy LSM and then with a real LSM, have allowed to validate the integration of the overall system by performing individual tests of the subsystem, checking I/O and communication, verifying the watchdog and the safety system, and verifying the flow control system. Additionally, the tests allowed to validate the system functionality, mainly by tuning and validating the system heating-up procedure and the procedure for coupling/decoupling of the hydrogen and syngas compressors.

The plant commissioning tests included the main functional and operational check tests. They allowed to check all I/O signals, required to effectively and safely operate the plant. Finally, the SAT has ensured that the prototype meets the specified requirements, design criteria, and functionality defined for the SWITCH system.

The system has proven to be ready for the following testing campaign in real operating conditions, including reversible operation.

# Annex I

*Table 1 Extract of the I/O check list*

| ***Sensor tag*** | ***unit*** | ***Description*** |
|---|---|---|
| DI_LSC03 | - | level switch |
| DI_PSC01 | - | pressure switch |
| DI_PSP01 | - | pressure switch |
| DI_PSP05 | - | pressure switch |
| DI_FSV01 | - | flow switch |
| DI_PSH01 | - | pressure switch |
| DI_TSV01 | - | temperature switch |
| DI_PSM03 | - | pressure switch |
| DI_PSM01 | - | pressure switch |
| DI_PSM02 | - | pressure switch |
| DI_TSM01 | - | temperature switch |
| DI_TSM02 | - | temperature switch |
| DI_TSM03 | - | temperature switch |
| DI_LSM01 | - | level switch |
| DI_LSM02 | - | level switch |
| DI_LSC01 | - | level switch |
| DI_LSC02 | - | level switch |
| DI_PSP02 | - | pressure switch |
| DI_FSP01 | - | flow switch |
| DI_FSP02 | - | flow switch |
| DI_LSC04 | - | level switch |
| DI_PSC02 | - | pressure switch |
| DI_FEC01 | slm | flow meter |
| DI_LSC05 | - | level switch |
| DI_LSC06 | - | level switch |
| DI_PSP07 | - | pressure switch |
| DI_FSP03 | - | flow switch |
| DI_FSP04 | - | flow switch |
| AI_PEP01 | mbarg | pressure sensor |
| AI_PEC02 | mbarg | pressure sensor |
| AI_PEC04 | mbarg | pressure sensor |
| AI_PEC09 | mbarg | pressure sensor |
| AI_PEC12 | mbarg | pressure sensor |
| AI_PEC14 | mbarg | pressure sensor |
| AI_TEP01 | C | Termocouple |
| AI_TEH05 | C | Termocouple |
| AI_TEC05 | C | Termocouple |
| AI_TEC06 | C | Termocouple |
| AI_TEC08 | C | Termocouple |
| AI_TEC09 | C | Termocouple |
| AI_TEC10 | C | Termocouple |
| AI_TEC11 | C | Termocouple |
| AI_TEC12 | C | Termocouple |

| | | |
|---|---|---|
| AI_TEH06 | C | Termocouple |
| AI_TEC18 | C | Termocouple |
| AI_TEC04 | C | Termocouple |
| AI_QEH03 | % | LEL sensor |
| AI_QEH04 | ppm | CO sensor |
| AI_FEH02 | m/s | Roof fan air speed |
| AI_TEH02 | C | Termocouple |
| AI_TEC07 | C | Termocouple |
| AI_QEH07 | % | LEL sensor |
| AI_QEH08 | ppm | CO sensor |
| AI_FEH04 | m/s | Roof fan air speed |
| AI_TEH04 | C | Termocouple |
| AI_QEP03 | % | LEL sensor |
| AI_QEC01 | ppm | CO sensor |
| AI_FEP02 | slm | flow meter |
| AI_PEP02 | mbarg | pressure sensor |
| AI_PEP03 | mbarg | pressure sensor |
| AI_PEP05 | mbarg | pressure sensor |
| AI_PEP18 | mbarg | pressure sensor |
| AI_PEP07 | mbarg | pressure sensor |
| AI_PEP08 | mbarg | pressure sensor |
| AI_PEP09 | mbarg | pressure sensor |
| AI_PEP11 | mbarg | pressure sensor |
| AI_PEP12 | mbarg | pressure sensor |
| AI_PEP13 | mbarg | pressure sensor |
| AI_PEP14 | mbarg | pressure sensor |
| AI_PEP15 | mbarg | pressure sensor |
| AI_PEC01 | mbarg | pressure sensor |
| AI_PEC11 | mbarg | pressure sensor |
| AI_PEC15 | mbarg | pressure sensor |
| AI_PEP20 | mbarg | pressure sensor |
| AI_QEH09 | % | LEL sensor |
| AI_QEH11 | ppm | CO sensor |
| AI_QEH10 | % | LEL sensor |
| AI_QEH12 | ppm | CO sensor |
| AI_TEP02 | C | Termocouple |
| AI_TEP03 | C | Termocouple |
| AI_TEP04 | C | Termocouple |
| AI_TEP05 | C | Termocouple |
| AI_TEP06 | C | Termocouple |
| AI_TEC01 | C | Termocouple |
| AI_TEC02 | C | Termocouple |
| AI_TEC03 | C | Termocouple |
| AI_TEC13 | C | Termocouple |
| AI_TEG90 | C | Termocouple |
| AI_PEC05 | barg | PSA unit pressure sensors |
| AI_PEC06 | barg | PSA unit pressure sensors |
| AI_PEC07 | barg | PSA unit pressure sensors |
| AI_PEC08 | barg | PSA unit pressure sensors |

| | | |
|---|---|---|
| AI_PEC10 | barg | PSA unit pressure sensors |
| AI_PEC03 | barg | PSA unit pressure sensors |
| AI_PEC13 | mbarg | pressure sensor |
| AI_PEC16 | mbarg | pressure sensor |
| AI_FEC02 | Slm | Flow meter |
| AI_FEP102 | Slm | Flow meter |
| AI_PEP16 | mbarg | pressure sensor |
| AI_PEP103 | mbarg | pressure sensor |
| AI_PEP105 | mbarg | pressure sensor |
| AI_PEP19 | mbarg | pressure sensor |
| AI_PEP111 | mbarg | pressure sensor |
| AI_PEP112 | mbarg | pressure sensor |
| AI_PEP113 | mbarg | pressure sensor |
| AI_PEP17 | mbarg | pressure sensor |
| AI_PEP115 | mbarg | pressure sensor |
| AI_PEC19 | mbarg | pressure sensor |
| AI_PEC17 | mbarg | pressure sensor |
| AI_PEC18 | mbarg | pressure sensor |
| AI_PEP21 | mbarg | pressure sensor |
| AI_QEH13 | % | LEL sensor |
| AI_QEH14 | ppm | CO sensor |
| AI_TEP07 | C | Termocouple |
| AI_TEP104 | C | Termocouple |
| AI_TEP105 | C | Termocouple |
| AI_TEP106 | C | Termocouple |
| AI_TEC14 | C | Termocouple |
| AI_TEC16 | C | Termocouple |
| AI_TEC15 | C | Termocouple |
| AI_TEC17 | C | Termocouple |
| AI_TEG90B | C | Termocouple |
| PN_FEP01_Act | slm | flow meter |
| PN_VgP104_Act | slm | MFC reading value |
| PN_VgP104_SP | slm | Set point MFC |
| PN_VgP14_Act | slm | MFC reading value |
| PN_VgP14_SP | slm | Set point MFC |
| PN_VgP30_Act | slm | MFC reading value |
| PN_VgP30_SP | slm | Set point MFC |
| PN_FEP03_Act | slm | flow meter |
| PN_FEP05_Act | slm | flow meter |
| PN_VgP57_Act | slm | MFC reading value |
| PN_VgP57_SP | slm | Set point MFC |
| PN_VgP62_Act | slm | MFC reading value |
| PN_VgP62_SP | slm | Set point MFC |
| PN_FEP103_Act | slm | flow meter |
| MB_H2Low_A | slm | set point H2 flow rate system A, low flow |
| MB_H2Low_B | slm | set point H2 flow rate system B, low flow |
| MB_H2High_A | slm | set point H2 flow rate system A, high flow |
| MB_H2High_B | slm | set point H2 flow rate system B, high flow |
| MB_NGRef_A | slm | set point NG to ref flow rate system A |

| | | |
|---|---|---|
| MB_NGRef_B | slm | set point NG to ref flow rate system B |
| MB_AirProc_A | slm | set point flow rate of Air To LSM system A |
| MB_AirProc_B | slm | set point flow rate of Air To LSM system B |
| MB_NGBur_A | slm | set point NG to burner flow rate system A |
| MB_NGBur_B | slm | set point NG to burner flow rate system B |
| MB_AirBur_A | slm | set point flow rate of Air To Burner system A |
| MB_AirBur_B | slm | set point flow rate of Air To Burner system B |
| MB_AirCool_A | slm | set point flow rate of Air To cooling system A |
| MB_AirCool_B | slm | set point flow rate of Air To cooling system B |
| MB_N2_A | mbar | set point N2 to burner flow rate system A |
| MB_N2_B | mbar | set point N2 to burner flow rate system B |
| MB_BPLSM_A | mbar | setpoint DP LSM A |
| MB_BPLSM_B | mbar | setpoint DP LSM B |
| MB_DPLSM_A | mbar | DP, actual value, system A |
| MB_DPLSM_B | mbar | DP, actual value, system B |
| TE-3101_A | C | system A, air IN Temperature |
| TE-3101_B | C | system B, air IN Temperature |
| TE-3102_A | C | system A, fuel IN Temperature |
| TE-3102_B | C | system B, fuel IN Temperature |
| SteamFlow_A | kg/h | steam flow rate to system A |
| SteamFlow_B | kg/h | steam flow rate to system B |
| kW_A | kW | Electrical power input to LSM system A |
| kW_B | kW | Electrical power input to LSM system A |
| AI_FEC01 | slm | PSA feed flow meter |