



<b>Technical Note</b>		<b>TN-030</b>	
<b>Test:</b> Direct HIUs heating test		<b>Test no.:</b> 1a, 1b, 1c, 1d, 1f and 1D	
<b>Assumption:</b> New test		<b>Assumption no.:</b>	
<b>Rev:</b> 04	<b>Date:</b> 09/05/2022	<b>Author:</b> Josu Aurrekoetxea	<b>Checked:</b> Neil Gatland

## 1. Introduction

The current Besa test is limited to twin plate instantaneous DHW and indirect heating HIUs. In order to expand the test to other type of HIUs it has been decided that an instantaneous DHW and direct heating HIU is the type that requires the smallest changes on the existing test rigs and the easiest to set up. Direct heating HIUs with a pump and a mixing circuit are not considered for this first direct HIU test development.

The DHW test should be the same as the existing indirect HIU test. The only changes required are on the heating test.

Direct heating HIUs considered for this test don't include a secondary heating pump nor a temperature control. These HIUs will allow the primary temperature directly to the radiators, fancoil or UFH and their return temperature will depend on the corresponding heating system. The most common apartment heating emitters used with this type of HIU are radiators, even though the HIU would also be appropriate for fancoil heating (less common in standard apartment buildings) and an UFH system with the pump and mixing valve inside the UFH manifold.

Since there is no flow temperature control in these HIUs, their only purpose is to keep the apartment heating system within the proper differential pressure (DP) conditions. Controlling the DP at the HIUs secondary, the flow rate through the emitters can be balanced and maintained as close as possible to the design conditions. Keeping the flow rate balanced at design conditions, the radiators can achieve design return temperatures. For this reason, the test will specifically monitor the DP and flow rate on the secondary side of the HIU. It is also important that the differential pressure does not cross the maximum limit allowed by the TRVs because this could lift the valves and force flow through the radiators when the room is already at set point temperature. Noise inside the apartment could be another problem caused by high DP at the apartment.

The proposed test would monitor the capacity of the HIU to keep the differential pressure constant at the apartment heating system. The purpose of this document is to set a DP for the test.

## 2. Considerations for DP set point selection

Radiators are the most common emitter installed with direct heating HIUs. Fancoils are less common, generally seen in high end developments, while UFH would require a more expensive mixing manifold. All options are possible but the test will use as a reference radiator circuits because they are the most common.

The most common radiator flow control is done with thermostatic radiator valves (TRVs). These valves are installed with a thermostatic actuator that closes when the room temperature reaches their set point. They are also used to balance the radiator system. These valves can be of three types:

- Standard TRVs: These are the most commonly used TRVs. They allow setting a static pressure drop. Their minimum differential pressure depends on the flow that they need to allow to the radiator. The maximum differential pressure is limited by the thermostatic actuator which could be lifted if the differential pressure increases above its limit. Some manufacturers recommend a lower maximum DP to avoid noises. Once set the flow will depend completely on the DP reaching the radiator.
- Dynamic Flow Control TRVs. These valves are similar to the PICVs. The flow can be set on the valve and if the DP across the valve is within a minimum and a maximum value the flow through the valve will be more or less constant.
- Return temperature control TRVs. These valves control the return temperature coming from the radiator.

In some cases, for example when there are zone valves instead of TRVs, radiator lockshield valves are used to balance the system. These would in many cases have similar DP requirements as TRVs. Lockshield valves do not have the same maximum DP limitation but in order to control the flows a low DP is recommended.

New apartment radiator flow rates are generally very small. Consequently, pressure drop of pipework and radiators is also very small and most of the pressure drop concentrates on the radiator balancing valves (TRVs, lockshield...).

The datasheet of 12 different radiator valves have been analysed. The result is as follows:

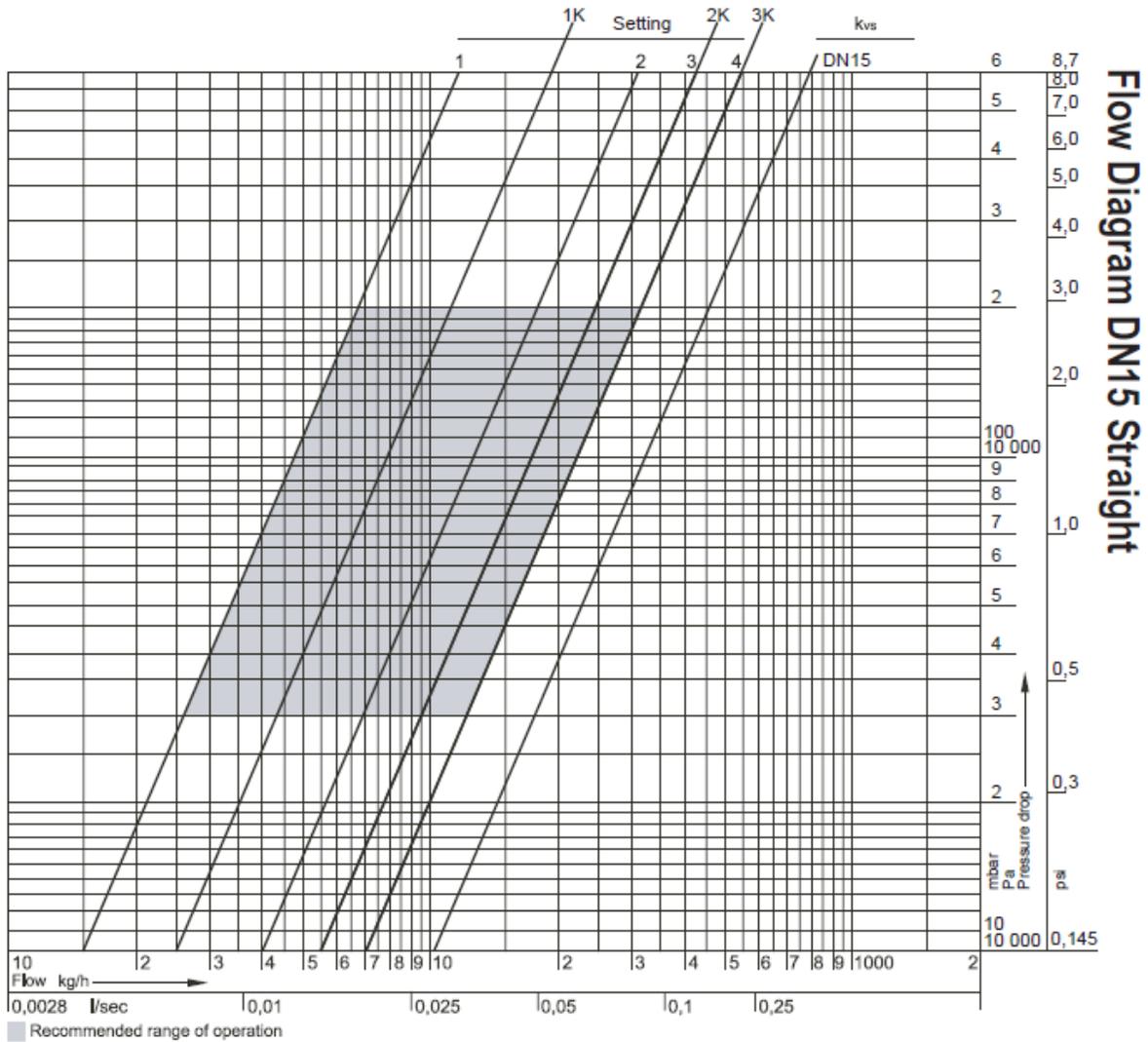
	<b>Supplier</b>	<b>TRV type</b>	<b>Minimum <math>\Delta P</math> (kPa)</b>	<b>Maximum <math>\Delta P</math> (kPa)</b>	<b>Extra comments</b>
Model 1	Brand 1	Dynamic flow	10 or 15	150	
Model 2	Brand 2	Dynamic flow	10	60	
Model 3	Brand 2	Return temperature	-	60	
Model 4	Brand 3	Dynamic flow	10	60	
Model 5	Brand 4	Dynamic flow	10	60	

Model 6	Brand 5	Dynamic flow	10 or 15	60	
Model 7	Brand 6	Dynamic flow	11 or 15	150	
Model 8	Brand 7	Standard	-	60	
Model 9	Brand 8	Standard	-	100	
Model 10	Brand 9	Standard	-	100	Not recommended more than 20 kPa because of noise
Model 11	Brand 9	Standard	-	100	Not recommended more than 20 kPa because of noise
Model 12	Brand 4	Standard	-	100	Not recommended more than 20 kPa because of noise

Table 1. TRV maximum and minimum DP

All the valves can work between 15 and 60 kPa differential pressure. It should be also noticed that standard TRVs are easier to set at low DPs, between 5 and 20 kPa.

The following diagram belongs to a standard TRV. It recommends DP between 3 and 20 kPa.



Graph 1: Standard TRV setting-DP-Flow chart

As a result, a safe DP for all radiator valves would be 15kPa. In order to allow some pressure drop for the rest of the heating circuit it is proposed to set the DP for radiator circuits at 20 kPa. This value works for all the reviewed valves and it keeps the DP reasonably low for standard TRVs. This DP would also be appropriate for UFH manifold with mixing circuit; however, it would be low for fancoil circuits with PICVs.

This value will only be applicable for HIUs that allow setting the DP of the heating secondary independently from DHW control.

### 3. Test objective, power and temperatures

The proposed test should replace the indirect HIU's tests 1a, 1b, 1c, 1d, 1e and 1f. In consequence the test simulated power should be 0.5kW, 1kW and 4 kW. The replaced tests include simulate apartment emitters operating at 55-35 °C and 45-35 °C, however, this kind of direct HIU would supply apartment heating system with the primary flow temperature, 70 °C in the case of tests 1a, 1b and 1c; 55 °C in tests 1d, 1e and 1f. With the purpose of equalising direct and indirect tests as much as possible it is proposed to have a heating reference temperature of 70-35 °C for the high temperature test and 55-35 °C for the low temperature test. It is assumed that a pump and a mixing valve are installed on the heating tertiary system in the HT test.

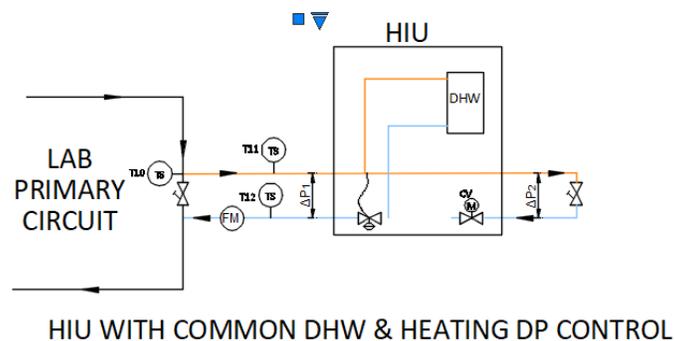
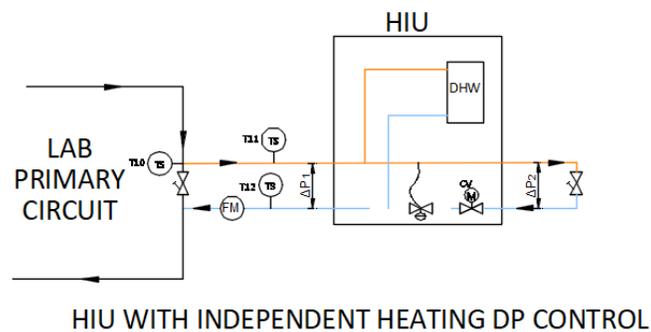
The following table summarises the conditions:

Test	kW	Temps. °C	Flow (l/s)
1a	0.5	70-35	0.003
1b	1	70-35	0.007
1c	4	70-35	0.027
1d	0.5	55-35	0.006
1e	1	55-35	0.012
1f	4	55-35	0.048

The purpose of this test is not to monitor the temperatures of the system because the HIU does not control the secondary temperature. This chapter considers the reference temperatures because they define the test flow rates. The test results will show the supply temperature with the purpose of ensuring same temperature conditions for all tested HIUs. It is proposed to test at 70 °C for HT conditions (flows) and 55 °C for LT conditions (flows).

The test will consist of setting the HIU and test rig to achieve 4kW flows with 50kPa on the primary side. The idea is to run the heating tests at different flow conditions modulating the DP on the primary and measure the flow and  $\Delta P$  changes on the secondary side of the HIU.

Notice that the return temperatures are not the same in as the indirect LT test. The temperatures have been chosen to be representative of real operational conditions. In no case the VWARD results of this test shall be used to compare direct and indirect HIUs. The selection of one technology or the other for a project shall never be based on return temperature alone.



#### **4. Test differential pressure**

2 types of DP control have been identified in direct HIUs:

Some direct HIUs include a common DP control for the DHW valve and heating. In those cases, the HIU shall be commissioned to a value that will be used for heating and DHW tests. The manufacturer will need to decide a set point adequate for all tests including the maximum DHW load test.

The initial commissioning of the DP of this HIU shall happen before starting any test and shall not be modified for any of the tests (DHW or heating).

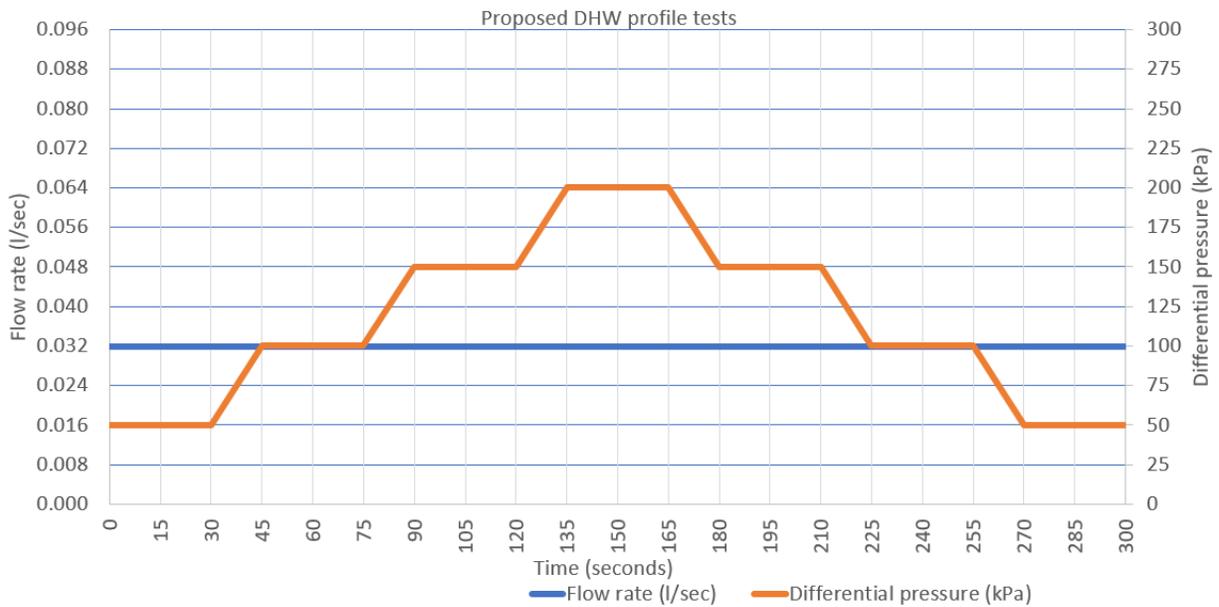
There are other HIUs that allow setting the DP independently from the DHW valve. These HIUs will be set to 20 kPa DP following the criteria explained in chapter 2 of this document. In this case, the HIU should be commissioned to achieve 20 kPa with 50 kPa of differential pressure on the primary side at 4kW conditions.

In both cases initial commissioning of the HIU requires the specific commissioning of the test rig. It is proposed to use 3 DRVs to set the flow on the secondary side to the test conditions. The flow through the HIU will depend on the DP of the secondary of the HIU and the resistance of the circuit downstream of the HIU.

In the case of HIUs that allow setting the DP set point, the test rig DRVs shall be commissioned with 20kPa DP to achieve the specific test flows. This 20 kPa will be reached by the test rig itself. Afterwards the HIU DPCV will be commissioned to achieve 4kW flow rate. 1kW and 0.5 kW test will be performed with the commissioning achieved for 4kW flow rate.

If the HIU does not allow to set the DP independently from DHW control the DPCV will be commissioned as per manufacturer standard procedure. The test rig 4kW flow DRV will be commissioned to achieve design flow rate with the HIU operating with 50kPa on its primary. The DP will be measured at the secondary during the 4kW DRV set up. The measured DP will be used to commission the 0.5 and 1kW test DRVs.

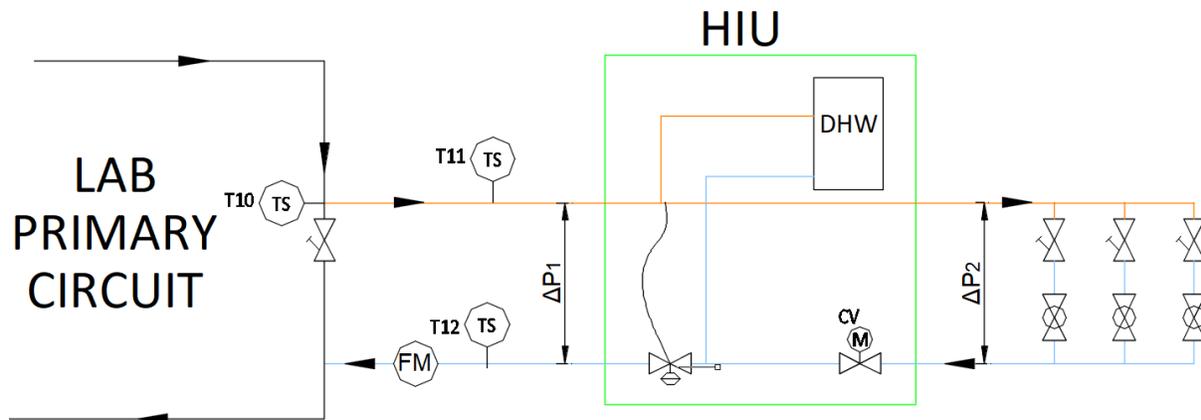
Once stable conditions are achieved the test rig should fluctuate the DP from 50 kPa to 2 bar in 50kPa steps and return back to 50 kPa. The initial proposal is 30 second steps once the pressure is reached with 15 seconds of pressure change period to avoid sudden changes.



The result should be presented as a graph in time showing primary DP, secondary DP and flow rate. DP shall never reach values higher than 60 kPa which is the most common high DP limit in radiator valves.

### 5. Test rig

The test rig should look like the following schematic:



Each of the DRVs will be individually commissioned to achieve different flows. The test house will open a DRV at the time for each of the heating loads. The test rig will control and modulate ΔP1 and monitor ΔP2.

### 6. Direct Heating and VWARD

It is proposed to use the resulting flow from the heating test to calculate the resulting VWARD. The text itself does not provide the return temperature of the test but would provide the flow. The return temperature can be calculated from the corresponding test flow temperature, power and resulting flow rate.

$$P = C_m \times F \times (T_{11} - T_{12}) \rightarrow T_{12} = T_{11} - P / (C_m \times F)$$

Where:

- P power of the specific test [kW]
- $C_m$  is Water Specific heat [4.18 kJ/kg\*°C]
- F is flow rate [kg/s]. The
- T11 is the test temperature (HT test 70°C and LT test 55°C)
- T12 is the return temperature for VWARD calculation.

## 7. Recommendation

- The HIU should be commissioned to 20 kPa on its secondary if the DHW is not affected by the differential pressure setting. In the case of the DP set point affecting the DHW test the manufacturer will choose the test set point.
- When the HIU heating DP setting affects the DHW performance the DHW and heating test are linked and all DHW tests shall be repeated if any change is done to the DP setting.
- It is recommended to commission the HIU with 50 kPa at the primary side and 4kW of demand. Lower power tests should be done with the same HIU set up.
- Report circuit temperature, primary DP, secondary DP and flow during the tests.
- Initial recommendation is to test the HIU with flows for  $\Delta T=35$  °C on the HT test and  $\Delta T=20$  °C in LT test.
- HIU should fail if the secondary  $\Delta P$  reaches more than 60 kPa, less than 10 kPa.
- Due to the relation between flow and DP, this document recommends setting the flows based on initial DP and allow the test record the evolution of secondary flow and DP without requiring the rig to match the test flows.
- VWARD calculation will consider the flow fluctuations during the test.
- Secondary flow difference with design flow shall be reported in percentage.

## 8. References

[1] Table 1 from various manufacturers

[2] Graph1: Honeywell Valencia Range valve Datasheet