DESIGO -

Energy-efficient applications: TABS Control

Application datasheet

Answers for infrastructure.

Table of contents

1 Brief introduction to TABS Control

Thermally activated building systems (TABS) refers to heating and cooling transmission systems taking advantage of large surface areas and integrated in the building structure. These type of systems take advantage of a building's mass, usually structural floors and slabs to thermally condition a building. Either TABS alone, or TABS supplemented by auxiliary systems, heats or cools the space. The concept required to thermally condition rooms places the highest possible demands on control technology. Siemens has recognized this fact and conducted intensive research together with renowned Swiss scientific institutions (EMPA, part of the Swiss Federal Institute of Technology, Lucerne University of Applied Sciences and Art). Comprehensive simulations under real-world conditions were conducted to research and develop new control strategies.

DESIGO TABS control meets these challenging requirements using a patented process and controls TABS zones for year-round fully automated operation. Innovative control functions including cyclical operation, i.e. where TABS controls thezone water circulation pump, deliver even greater benefits; including savings of up to 60% on the electricity required to operate such pumps in a typical office building.

The innovative application is modular in design. The base control strategy can be extended by optional modules to improve comfort and/or energy efficiency depending on given requirements and TABS plants.

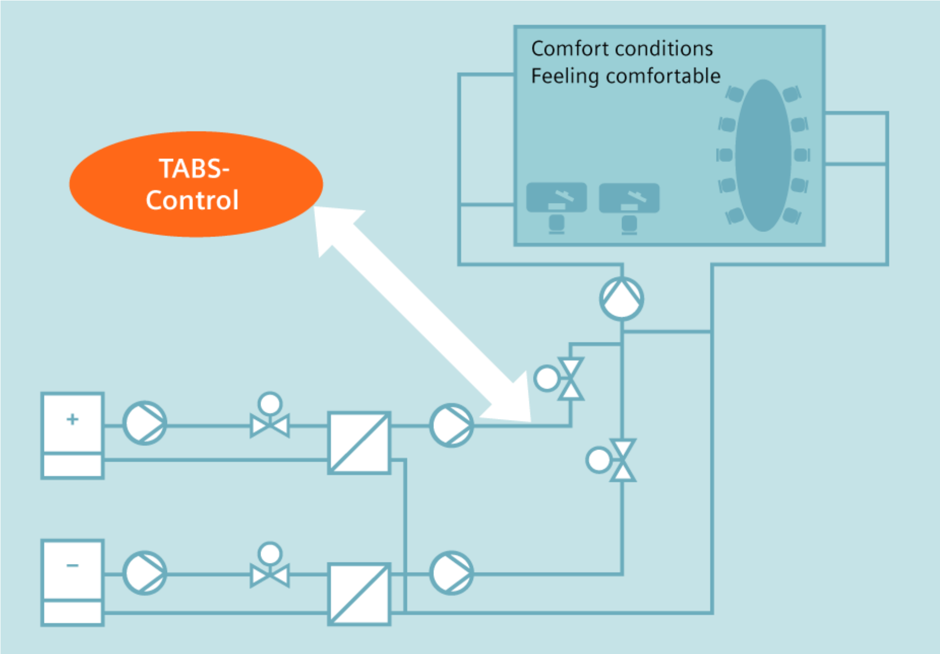


Figure 1-1
Rough diagram of a TABS plant – the TABS Control application is responsible for controlling the TABS zone(s)

2 Basics

Ever greater demands placed on room conditions, as well as a growing awareness of the need to reduce energy consumption, demand new forward-looking building concepts. Thermally Activated Building Systems (TABS) is an innovative technology that rises to the challenge.

Thermally activated building systems (i.e. typically the building structure) are considered a targeted part of energy management to increase energy efficiency. However, the rapidity of heat and cold transfer is deterred by the considerable system inertia inherent in the thermal activation of a large mass. This must be considered for control and when engineering TABS. Matching is dynamic in nature throughout the entire daytime, nighttime cycle.

Heating and cooling using tube heat exchangers embedded in concrete elements

The concrete floors are used for most TABS applications as the heat and cold transfer system within the building. This is referred to as concrete core temperature control. To this end, coils consisting of plastic or composite tubes are cast directly in the concrete core of the slabs or floors. As most heat transfer takes place through the ceiling and not the floor, the tubes are often fixed nearer to the thermally effective ceiling surfaces (see Figure 2-1). The tubing systems form closed water circuits used to heat or cool the concrete thermal mass. System temperature differentials (i.e. the difference between flow and return temperatures) can be held at minimum, due to the relatively large transfer area. The exposed concrete surfaces provide a natural temperature adjustment to the adjoining rooms.

The concrete floor absorbs excess heat and cools the room. The level of self-regulation is quite high due to the low system temperature differential. This effect lessens undesired under cooling or overheating of individual rooms within a TABS zone. The high degree of thermal storage makes it possible to time-shift plant operation. Auxiliary systems are required to provide individual room temperature control within a TABS zone. A flow temperature approaching the room temperature allows operators to efficiently heat, for example, using heat pumps. Environmentally friendly sources of cooling energy include free cooling, re-cooling, or ground water cooling..

Buildings featuring TABS have a high level of room comfort. This is achieved by carefully initiating measures that are matched to one another consisting of the following basic elements: very good heat and solar protection, sufficient thermal building storage capacity, sealed exterior shell together with basic ventilation and air exchange sufficient to ensure proper hygiene as well as heat recovery.
And of course, integrated engineering is extremely important to achieve continuous levels of energy efficiency for the overall system.

Advantages

- As well heat delivery for heating as heat absorption for cooling takes occur by the thermally activated building systems with their large transfer surfaces
- Low system temperature differentials (due to the large transfer surfaces).
- Efficient use of natural sources of energy: e.g. heating using heat pumps or cooling from free cooling, re-cooling or ground water cooling.
- Time-shifted heat delivery and heat absorption by means of large thermal mass.
- Use of cooler outside air at night during the summer or operation of heat pumps during periods when electrical tariffs are lower.

- Energy efficient, self-regulating heat and cold generation control of the room temperature.
- Low building and maintenance costs.

Constraints

- Additional inertia caused from ceiling/flooring, e.g. raised floors, suspended ceilings or insulation must be considered.
- Thermal comfort cannot be adjusted to suit everyone: a certain level of room-temperature fluctuation throughout the day must be expected.
- Challenging engineering, especially with regard to heat loads that must be estimated as part of the planning process.

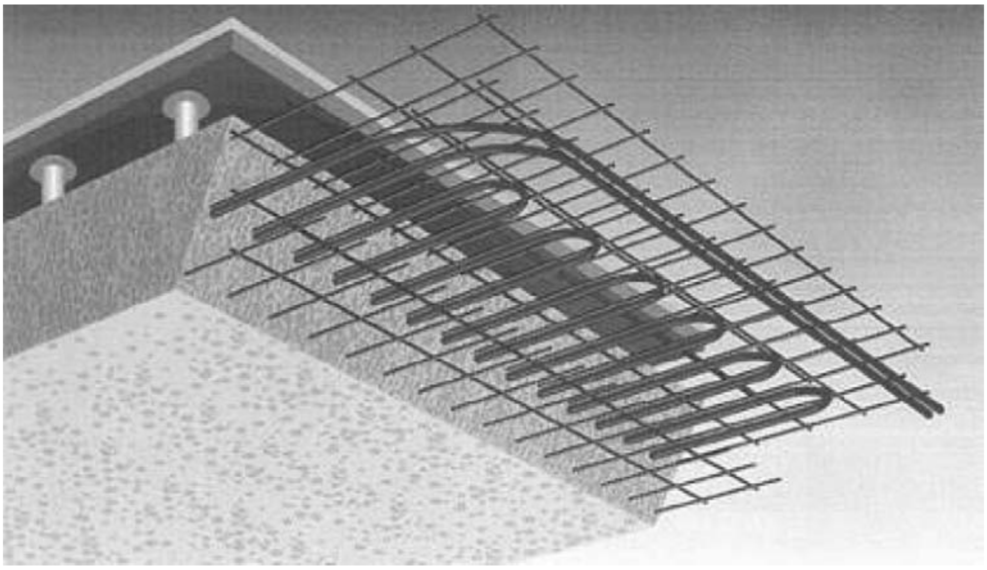


Figure 2-1
Embedded pipework for tempering the exposed ceiling (Source: Zent-Frenger)

3 TABS control

3.1 Overview

TABS require special control for zones, energy generation and distribution. They can be dealt with in the same manner as for other heat and cold transfer systems. Zone control distributes heat and cold within a TABS zone based on demand. The same flow piping generally supplies multiple rooms, i.e. the rooms are grouped into zones.

The TABS control application controls the flow temperature for a zone dependent on climatic conditions using two modulating valves and a pump. The TABS control application is divided into four modules (see Figure 3-1):

- Room temperature control to increase comfort level (1).
- Heating and cooling curves (including heating and cooling limits) to determine flow temperature (2).
- Cycle operation to increase overall energy efficiency (3).
- Sequence control (4).

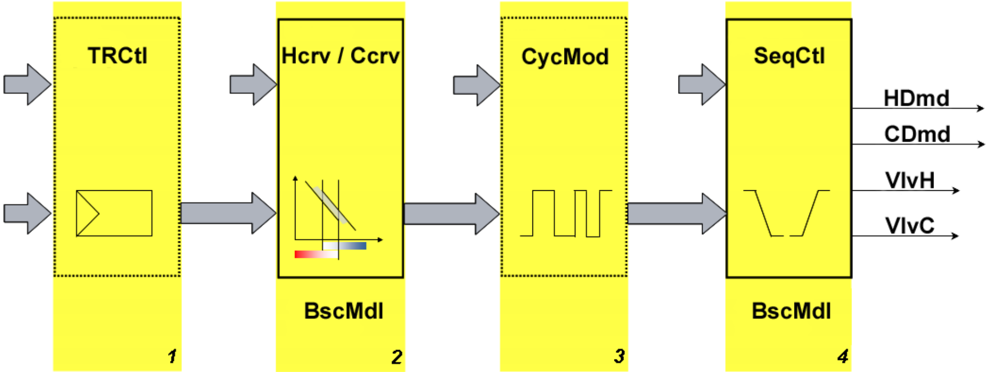


Figure 3-1
Modular design of TABS control application

BscMdl	Basic module	Hcrv	Heating curve
Ccrv	Cooling curve	SeqCtl	Sequence control
CycMod	Cycle operation	TRCtl	Room temperature control

Basic module
At a minimum, the basic modules heating and cooling curves (2) as well as sequence control (4) are required for zone control.

Supplementary modules
A room-temperature control module (1) can be used as an option to increase comfort level. The cycle operation module (3) can be used as an option to operate the zone pumps intermittently and to adjust the temperature of the concrete core in an environmentally and less costly manner.

The principal functions are explained in greater detail below.

3.2 The principal functions

3.2.1 Heating and cooling curve module

Advantages:
- High level of room comfort.
- Fully automatic changeover between heating and cooling.
- Permits/disables general heating or cooling operations dependent on outside temperature.
- Scheduled shift of flow temperature setpoints (e.g. weekend operation).

The innovative heating and cooling curve module controls flow temperature for one heating circuit. The heating and cooling curves are based on mean outside air temperature over the past 24 hours (sliding time window). The heating and cooling curve is derived on the mean outside air temperature and the required flow temperature setpoint to ensure the desired level of room comfort.

The nominal heating and cooling curves apply to the nominal room temperature setpoints for heating and cooling. The heating and cooling curves are adjusted accordingly when the desired room temperature setpoints do not equal the nominal room temperature setpoints.

The time scheduled shift of the heating and cooling curves is used when it is known in advance that heat gains will vary significantly in the rooms of a zone on specific days. This shift is typically used to compensate for a lack of heat gain caused by non-occupancy over the weekends or during the holidays. The heating and cooling curves are adjusted upward for these periods.

The heating and cooling limits are established based on the average outside air temperature, which in turn enables heating and cooling modes. The module can be optionally configured for Summer/Winter compensation to further improve comfort conditions.

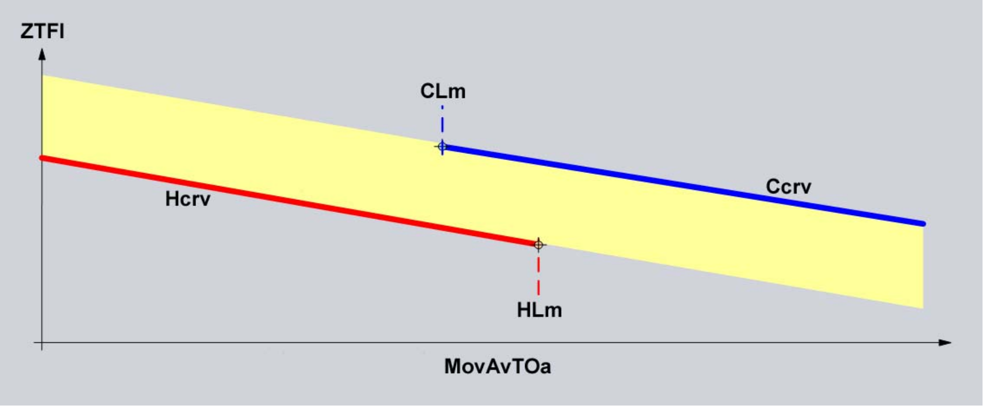


Figure 2-3
Heating and cooling curves as well as heating and cooling limits.
Note: The cooling limit can be lower than the heating limit (as is the case here)

Ccrv	Cooling curve	HLm	Heating limit
CLm	Cooling limit	MovAvTOa	Moving average outside temperature
Hcrv	Heating curve	ZTFl	Zone flow temperature

3.2.2 Sequence control module

Advantages:

- Demand-dependent changeover between heating and cooling mode.
- No simultaneous heating and cooling.
- Supports purge function for energy-efficient cycle operation.

The sequence control module controls valves and pumps for the heating and cooling mixing circuit. This type of control was predestined for a hydraulics topology that allows the zone to draw hot or cold water and control the flow temperature via separate heating and cooling valves.

Control of the flow temperature to the preset flow temperature setpoint range occurs using a sequence controller with two sequence elements (similar to supply air control for ventilation plants).

The purge operation acts on the zone pump and valves: The zone pump is switched on and the valves closed to allow for circulation of the heating/cooling media within the zone. The purge mode is needed to acquire the concrete core temperature after a switch-off phase and to determine the next heating or cooling action.

3.2.3 Room temperature control mode

Advantages:

- High level of room comfort.
- Adjustment to the room temperature setpoint for heating and cooling curves for additional comfort.
- No overheating or under-cooling.
- Separate switch on/off of room-temperature control to control heating and cooling setpoints.

The module may be enabled as an option if TABS room-temperature control is desired. Changes to the room temperature setpoint have a considerable lag due to the high degree of thermal inertia of TABS. Corrections are usually only possible on a day-to-day basis. The desired level of comfort is maintained by relying on one or more representative room temperature measurements in the zone without causing overheating or under-cooling.

Note:
Room temperature control is only possible where no auxiliary system assumes control of the room temperature. For example, TABS room temperature control must be switched off in rooms where auxiliary heating systems are available and controlling the room temperature. Nevertheless, room temperature control can continue to be used for cooling.

3.2.4 Cycle operation module (Energy efficiency module)

Advantages:

- Tremendous potential to save electricity by reducing zone pump operation: up to 60% savings in electricity is possible.
- Efficient use of natural and less-expensive energy sources.

Buildings featuring TABS offer energy efficient operation by design, and energy efficiency is the focus of tested (and proven) DESIGO applications. The TABS control application with its patented process, including the cycle operation modules allow TABS buildings to achieve even greater energy savings.

For heating, zone pump runtimes can be dramatically reduced by charging the concrete core using a slightly higher flow temperature during cycle operation.

The same applies to cooling. Electricity use by zone pumps can be reduced by up to 60%.

In addition to reducing pump energy, cycle operation can also "position" the switch on phases to take advantage of energy-efficient or less expensive sources of heat or cold including

- Using free re-cooling during the night.
- Using heat pump operation at low-cost nighttime rates.

3.2.5 Additional functions

There are numerous additional functions supported by TABS:

- Modular designed standard library applications including graphics for plant operation (using DESIGO INSIGHT to visualize and operate the TABS building).
- TABS building control using various plant configurations.
- Fault shut down to maximum plant and life safety.
- Trending and monitoring for heat/cold consumers and room data.

4 Energy savings

The energy efficiency was investigated as part of comprehensive simulations. The following is a brief summary of the results of a case study conduced jointly with the EMPA (Swiss Federal Laboratories for Materials Science and Technology). The study confirmed that operating a TABS building using DESIGO TABS control is very economical without sacrificing comfort.

The simulations corresponded to a typical office building in the Zurich region. During active heating, zone pump cycle operation reduced electricity use by up to 80%. The savings were limited to ca. 60% overall since cycle operation starts with a purge prior to normal switch-on to determine the temperature of the concrete core.

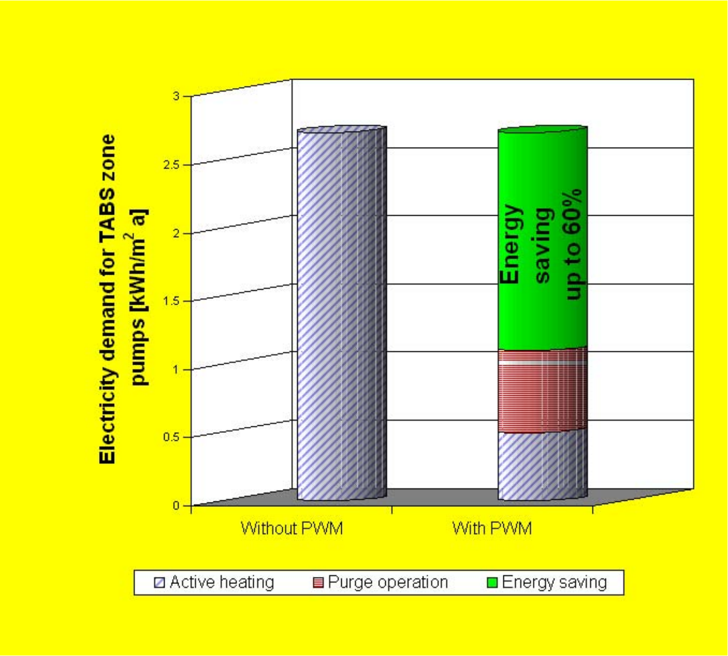


Figure 4-1
Pump electricity savings.

Key:

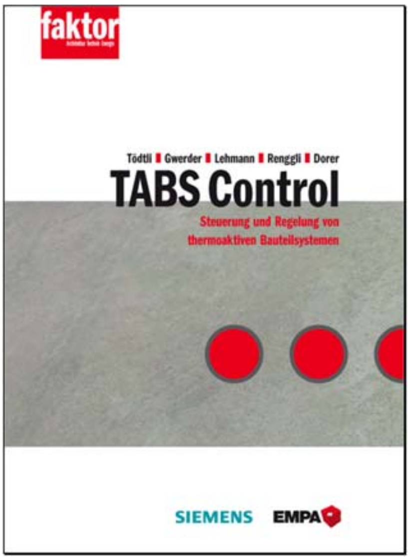
Without cycle operation	Refrigeration machine without free cooling, separate return piping / continuous heating mode.
With cycle operation	Refrigeration machine without free cooling, separate return piping / cycled heating mode.

Detailed results of the simulation are available in the comprehensive publication entitled "Thermally activated building systems (TABS): Energy efficiency as a function of control strategy, hydronic circuit topology and (cold) generation system" and can be ordered at http://dx.doi.org/10.1016/j.apenergy.2010.08.010 .

5 Planning manual: TABS control

Additional details on TABS control are available in the planning manual which is a joint product of Siemens BT and EMPA (Swiss Federal Laboratories for Materials Testing and Research) http://www.empa.ch .

The manual provides professional engineers, builders and operators with a comprehensive description of methods and solutions to design, control and operate TABS technologies.



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TABS Control

Steuerung und Regelung von thermoaktiven Bauteilsystemen

SIEMENS EMPA

Figure 5-1:
Planning manual: TABS Control

The manual is currently available in German only:

TABS Control - Regelung und Steuerung von thermoaktiven Bauteilsystemen
ISBN 978-3-905711-05-9, Faktor publishing house, Zurich, 2009
http://www.faktor.ch

6 Engineering tool TABSDesign

The TABSDesign engineering tool is available as a supplement to the planning manual. It is available in German only:

TABSDesign: Planning tool for thermally activated building systems.
Free download from the Faktor publishing house, Zurich, http://www.faktor.ch.

7 Advantages and customer benefits

7.1 Advantages

- Tested control strategy as an integral part of a TABS building.
- Low energy demand.
- Meets comfort requirements.
- Year-round fully automated operation.
- User-friendly operation using DESIGO INSIGHT.
- Comfort control by maintaining temperature limits.
- Modular designed standard library applications to simplify engineering and commissioning

7.2 Customer benefits

- Energy use reductions result in cost savings.
- Sustainable reduction of CO_2 emissions through the efficient use of thermally activated building systems.
- Time and costs savings during engineering, commissioning and occupancy phases as well as lower service costs thanks to tested applications and detailed documentation.
- Reduced maintenance services result in lower operating costs.
- Mastering challenging control technologies underscores the innovative nature of participating companies.
- Achieves the highest energy perfomance class in EN 15232 and increases the value of the plant as well as the building's potential sale value.

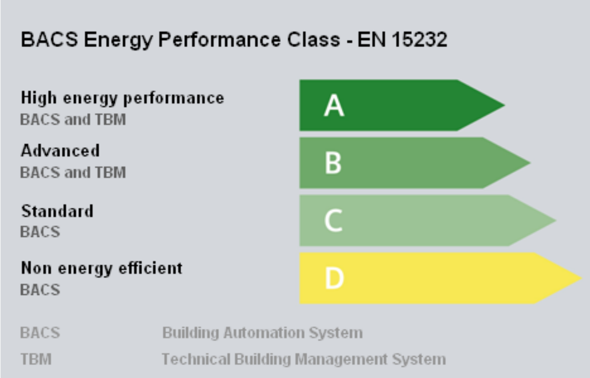


Figure 7-1

8 Field of application

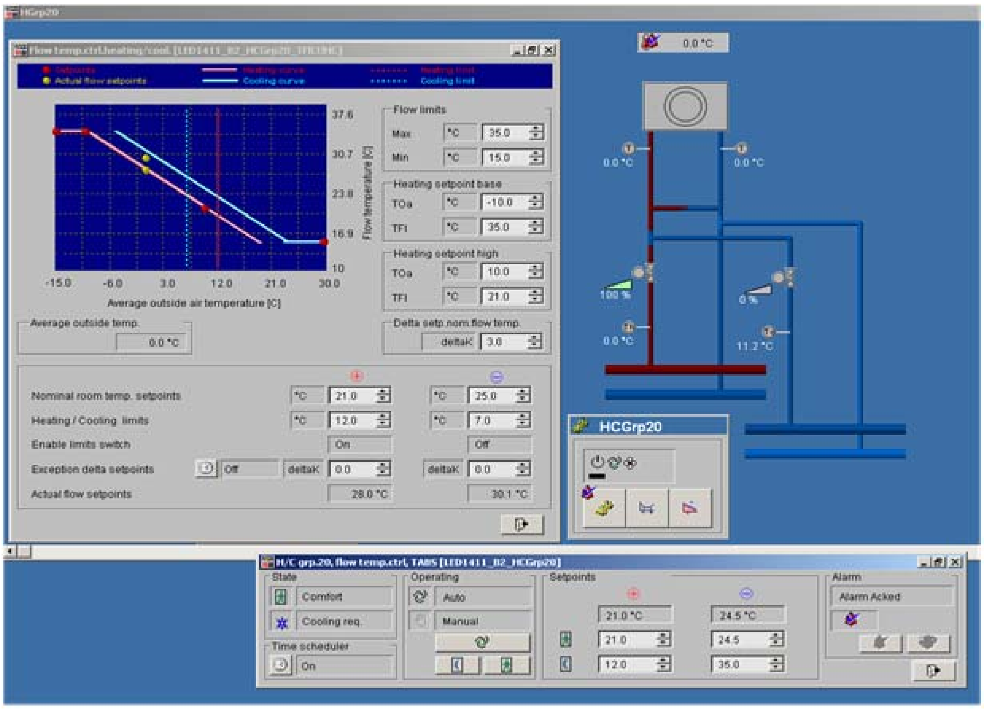
The TABS control application is suitable for all types of building use, e.g. for the building listed below, including:

- Office buildings.
- Manufacturing and assembly halls.
- Reception areas, bank tellers and lobbies.
- Warehouses
- Apartment buildings.

The application can be applied to both new and existing TABS buildings.

9 Display and operation

Prepared plant diagrams as well as views for operation and monitoring are already available for the TABS application as part of DESIGO INSIGHT.



Flow limits

Max °C 35.0

Min °C 15.0

Heating setpoint base

TOa °C -10.0

TFl °C 35.0

Heating setpoint high

TOa °C 10.0

TFl °C 21.0

Average outside temp. 0.0 °C

Delta setp.nom.flow temp. deltaK 3.0

Nominal room temp. setpoints	°C 21.0	°C 25.0
Heating / Cooling limits	°C 12.0	°C 7.0
Enable limits switch	On	Off
Exception delta setpoints Off	deltaK 0.0	deltaK 0.0
Actual flow setpoints	28.0 °C	30.1 °C

State: Comfort; Cooling req.

Time scheduler: On

Operating: Auto; Manual

Setpoints: 21.0 °C, 24.5 °C; 21.0, 24.5; 12.0, 35.0

Alarm: Alarm Acked

Figure 9-1
Overview featuring the main plant and details for optimized plant operation.

10 System hardware

The TABS control application is approved for installation on the primary automation station PXC.

11 Field devices

Siemens field devices or equivalent products should be used whenever possible.

12 Versioning

TABS control can be used as of DESIGO V4.0.

13 Comprehensive operation

TABS control is an important element for the successful operation of a TABS building. The DESIGO system ensures comprehensive energy efficiency from generation to consumers.

Multi-facetted applications, including:
- Heat pump integration and control.
- Coordination of cooling towers.
- Shading system control.
- Auxiliary system control.

guarantee safe and reliable operation throughout the entire plant life cycle.

14 Appendix

14.1 Plant components

The TABS control application is modular in design with variants and options in the widest possible range to customize the application.

Components supported by TABS control application:

Components	TABS control	Comment
Zone control		
Outside temperature sensor	X	
Flow temperature sensor	X	
Valve actuator, modulating (cooling)	X	
Valve actuator, modulating (heating)	X	
Single-stage zone pump	X	
Room		
Temperature sensor	O	
Room manual switch (Auto, Off, On)	O	
Setpoint temperature adjustment	O	
Room operating unit QAX per PPS2 interface.	O	Room operating units may be engineered at additional expense.

Table 14-1

X Supported

O Optional

14.2 Supported and recommended hydraulic circuits

The application supports all hydraulic circuits that allow a virtually constant flow through TABS when the zone pump is switched on as well as for flow temperature control that heats or cools based on demand.

Hydraulic circuits with common zone return piping may result in considerably more energy costs versus circuits with separate zone return pipes (see Table 14-2) due to losses from mixing. Furthermore, common zone return permits only a limited purge function for cycle operation.

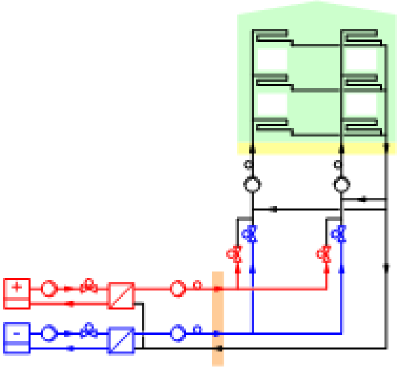
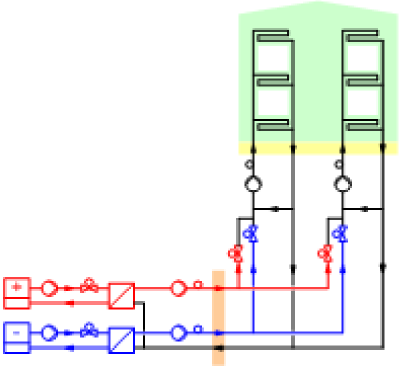
Hydraulics topology	 Figure 14-1	 Figure 14-2
Distribution piping	**Three** distribution pipes with **common** zone return line.	**Three** distribution pipes **with separate** zone return line.
Energy consumption for heat generation	**136** MJ/(m^2a)	**97** MJ/(m^2a) **Savings: 28%.**
Energy consumption for cold generation	**126** MJ/(m^2a)	**88** MJ/(m^2a). **Savings: 30%.**

Table 14-2
Results of annual simulation: Office building in Zurich

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