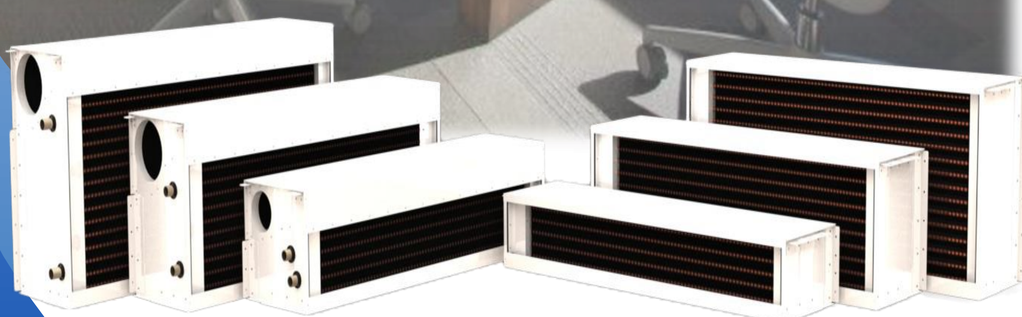
Passive & Active Thermosiphon Beams

-For more comfortable and energy efficient air-conditioning applications



Breeding a better environment into your building

Air T&D Pte. Ltd

Introduction

Buildings come in all shapes and sizes and are designed for different purposes. In order to create healthy and productive environments, air distribution systems must be carefully selected that meet the requests of designers. There are a wide range of choices available for air terminals in the market. In many cases, however, Passive Thermosiphon Beams (PTB) and Active Thermosiphon Beams (ATB) can be singled out as the best solution in terms of cost, comfort and energy. Air T&D's PTB and ATB systems are ideally suited for most applications, particularly for:

- Small and open plan offices
- Conference rooms
- Recording and TV studios
- Hotel rooms
- Bank halls
- Retail shops
- Public access areas
- Reception areas
- Printing and paper works
- Assembly and production factories
- Educational facilities
- Laboratories
- Restaurants and Cafeterias
- …

The purpose of this brochure is to briefly explain how PTB/ATB systems work and present relevant products supplied by Air T&D Pte. Ltd. More information on the design, installation, commissioning, operation and maintenance can be found in "Guidelines for Design and Applications of Passive and Active Thermosiphon Beams". Furthermore, an automatic selection program for terminal unit is also available for the end users.

Air Ventilation Schemes

In general, there are two common air distribution schemes in Air Conditioning and Mechanical Ventilation (ACMV) systems, *displacement air distribution* and *mixed air distribution*. Each scheme has its own characteristics. As shown in Figure 1, in fully-stratified displacement air distribution systems, cool supply air is typically delivered at reduced velocity from low sidewall or floor diffusers. The supply air is always cooler than the room air, so it quickly drops to the floor and spread out across the room. When this moving air mass encounters a heat load, it rises and carries the heat and pollutants towards the ceiling. A layer of warm air forms above the occupied zone due to natural thermosiphon effect. Internal heat loads and contaminants are carried away by the exhaust air.

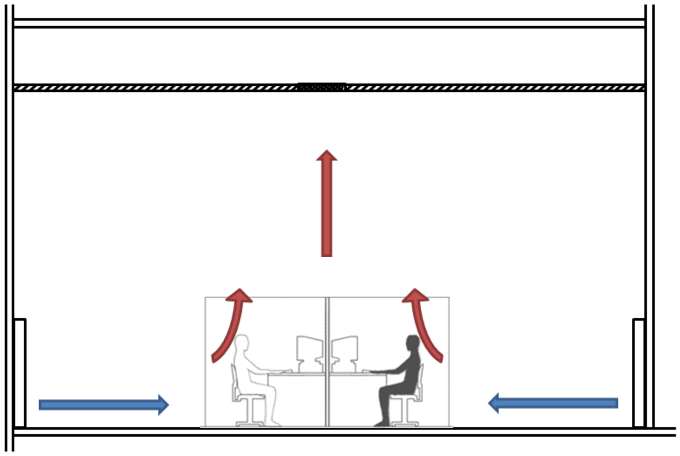


Figure 1 Displacement Air Distribution

By contrast, in mixed air distribution systems, cool supply air is delivered at relatively high velocity from ceiling-mounted diffusers, as shown in Figure 2. When ceiling diffusers are properly selected and positioned, this high velocity air doesn't result in occupant discomfort as it is delivered outside the occupied zone. The purpose of the high velocity air supply is to create low velocity room air motion in occupied zone through entrainment. Ideally, this air motion will thoroughly mix the supply air with the room air resulting in uniform temperature and contaminant levels throughout the occupied zone. Internal heat loads and contaminants are eventually picked up and carried away by the exhaust air.

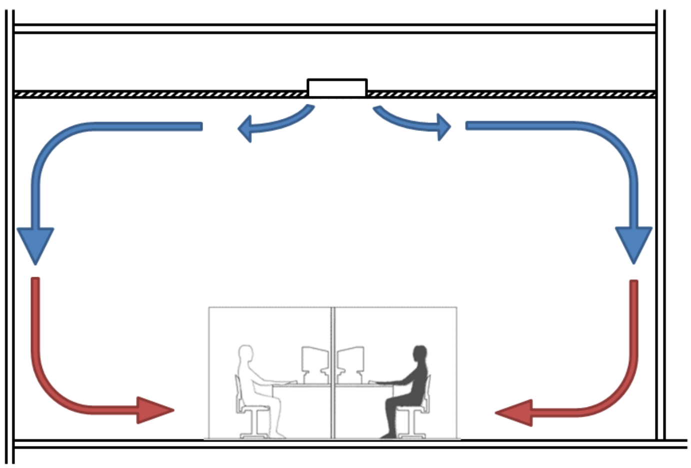


Figure 2 Mixed Air Distribution

The advantages of displacement air distribution compared with mixed air distribution scheme may include:

Improved Indoor Environmental Quality (IEQ): With high ventilation efficiency, displacement air distribution can reduce ventilation air requirement and comfort complaints due to drafts while improve the removal of airborne contaminants. Low air velocity also resulting low plume pressure inside the terminal units, consequently, the noise level is much lower.

Energy savings: The requirement for reduced ventilation air results in less energy consumption for fresh air treatment. This is especially significant in humid climates, where dehumidification of outdoor air is a significant cost. Since the plume pressure inside the terminal units is low, energy consumption of supply air fans can also be reduced.

Increased flexibility: The characteristic of supply air moving slowly across conditioned spaces gives the capability to manage indoor environment (i.e. space rearrangements, load distribution changes, etc.) efficiently throughout the lifetime of building.

However, the conventional displacement air distribution scheme is basically an all-air system; most of the warm air needs to be recirculated to plant rooms and mixed with the fresh air in order to complete the air circulation. The energy efficiency of the scheme is still relatively low that is a critical limitation for its wider applications.

Passive Thermosiphon Beams

As shown in Figure 3, cooling beams are installed in the layer of warm air formed above the occupied zone. The warm air at the high level are pushed through cooling beams. After cooling, the air is heavier and falls into the vertical fall duct and discharged at the floor level. The air is then heated by internal heat loads and rises to the ceiling level again. As long as the internal heat loads are maintained, the thermosiphon cycle continues. Thus, the whole air conditioning process is completed within the occupied zones without external driving force (fan).

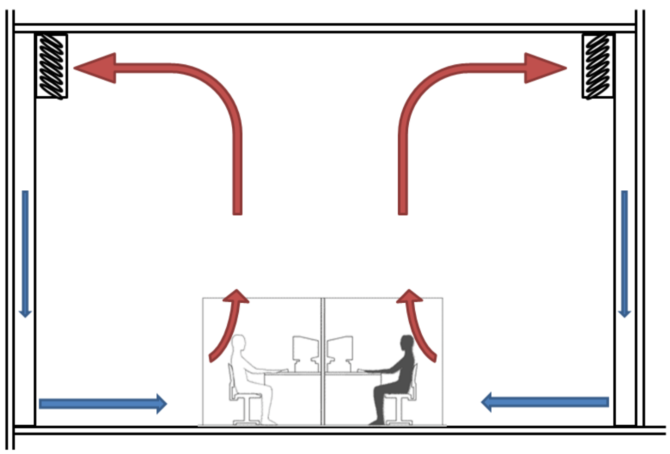


Figure 3 Passive Thermosiphon Beams

In many applications, the full fall duct may not be desirable and/or the load has large variations during the cooling period. In such cases, the fall duct can be replaced by a short air straightener and place a small fan (less than 10W) along the airflow path (shown as in Fig. 4) with very low fan speed so that there will be no noise impact. Experiments showed that the performance can be improved substantially compared with the PTB with full fall duct. In such implementation, the fan can perform three functions:

1) initialize or speed up the formation of airflow circulation in the startup phase;
2) provide better match the load variation through control of the air flow rate;
3) push the air through the coil and drop to the floor level for heating applications

When the fan is switched off, the system back to the conventional PTBs and its performance follows the specifications of normal PTB at the same condition.

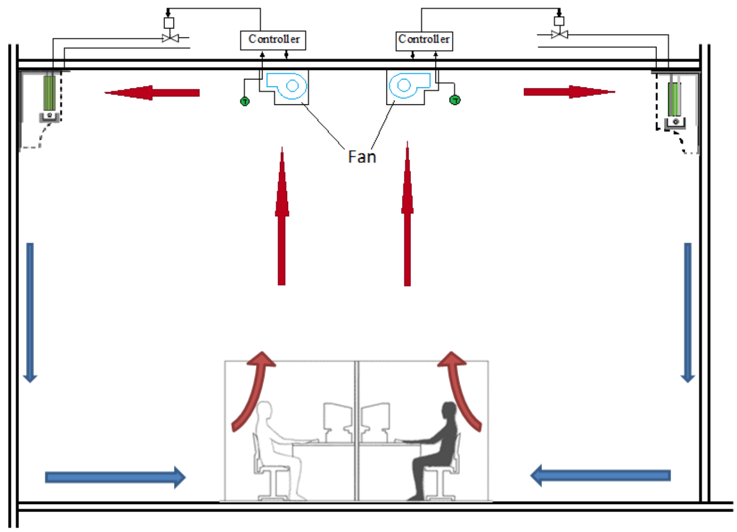


Figure 4 PTB with fan

With such air circulation loops, the benefits of displacement air distribution can be maximized as the need for the air recirculate to the plant room is eliminated. More importantly, additional energy saving can be inherited from cooling beams, as most of the cooling loads can be dissipated with chilled water rather than cooled air. The additional advantages also include but not limited to

- Significant savings in terms of ceiling space
- Much smaller foot print of primary air handling unit
- Conventional equipment requirement
- Less installation and maintenance cost

Active Thermosiphon Beams

Relevant laws and regulations provide that commercially used spaces must have a fresh air flow at least 6-9 $m^3/(h \cdot m^2)$ or a change of fresh air 2-3 times the room volume to comply with air hygiene requirements. Since the percentage of fresh air is relatively small compared to the total air to balance the internal cooling load, maintain the fresh air to the minimal value can thus significantly reduce the size of air supply systems and save investment and running costs. In PTB, there are two methods for the fresh air supply or ventilation:

1. supplied from central plants by a dedicated outdoor air system;
2. inject the warm outdoor air direct into ceiling space to mix with room recirculation air.

Air T&D proposes a novel terminal unit, ATB, which incorporates the fresh air as primary air into PTB in an efficient way as shown in Figure 5, the working principle of ATB can be interpreted as below:

- The fresh air is delivered as primary air into the primary air plenum and ejected through the nozzles into the mixing chamber on its way to the conditioned space.
- As air flows through the nozzle, a low pressure kernel is created surrounding the primary air stream at the outlet of the nozzle. This resulting in a low pressure area immediately at the nozzle outlet.
- The low pressure kernel attracts the surrounding air which is at a higher pressure than that of the low pressure kernel. Air from the conditioned space, known as secondary air, is drawn or induced into the low pressure kernel.
- A cooling beam is imposed in the path way of the room secondary air, forcing the induced air to pass through the beam and been cooled on its way to join the primary air stream.

Compared with PTB, the primary air in ATB serves as the fresh air supply which also increases the room air passing through cooling beams. As a consequence, both the cooling capacity and the air circulation within the occupied zone are also increased. In addition, cutting off the primary air supply makes ATB back to PTB operating mode.

Air T&D believes ATB system can be a better choice if they can be properly designed, implemented and operated.

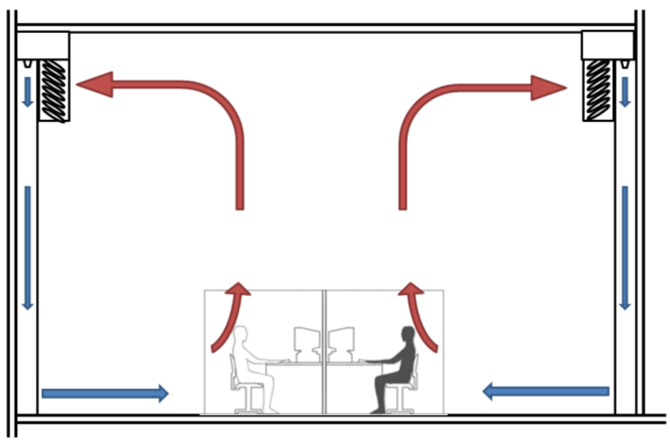


Figure 5 Active Thermosiphon Beams

Technologies and Resources

Since the working principles for both PTB and ATB systems are based on natural physical phenomena, such as Thermosiphon, Entrainment, Coanda and Displacement effects, many factors will affect their performances, including

Cooling beams: They are not a standard “off the shelf” component but need to be specially designed to maximize the heat exchange efficiency and minimize the pressure drop both on air and water loops at the low air flow rate condition

- Coil circuits
- Copper pipe diameter

- Fin design and shape
- Fin spacing
- Pipe spacing

Primary air supply loop (for ATB only): The efficiency of the induction process is dependent on the number, size and individual efficiency of the induction nozzles, the geometry of the cooling beam and

- Primary and mixing chamber geometries
- Nozzle geometry and arrangement

Overall system layout: The installed system performance is closely dependent on the system layout and quality of each component

- The beam installation height
- The fall duct length
- The fall duct depth, width, smoothness and insulation
- The free cross-section of the inlet and outlet gratings

Control system: For safe and efficient operation of the system, at least one of the following control loops is required**.** In some cases, three control loops are necessary to achieve the desired performance

- Fan speed control
- Chilled water flow rate control
- Primary air pressure control
- Fresh air supply control

To maximize the full potential of PTB and ATB, Air T&D together with Office for Development & Facility Management of Nanyang Technology University, Consultants and Manufactures has devoted tremendous efforts on various innovative technologies to optimize their performance. Through years of R&D efforts, we now can provide following technical supports for our clients.

Computational Fluid Dynamics (CFD) Modeling

CFD provides a means to validate design before construction, giving the customer confidence that the system will perform as intended in the field. Air T&D encourages designers to work with us to validate their designs.

Software Tools

Air T&D's software features a unique ranking engine that automates the selection process, making it easier for an engineer to select the right ACMV terminal units based on the criteria that is important to them.

Green Cooling & Air-conditioning Technologies Lab (GCAT-Lab)

Air T&D's state-of-the-art research facilities mainly include an advanced Green Cooling & Air-conditioning Technologies Lab in Nanyang Technological University, Singapore. This lab allows designers to simulate field conditions and evaluate system performance, providing them with the confidence that our products will perform as expected.

Applications Support

Air T&D is a service oriented company and has a dedicated applications team devoted to answering your questions quickly, completely, and correctly. Our applications team regularly provides support on model selection, layout assistance, calculation assistance, on-site training, on-site performance validation, etc.

Mockups

The various combinations and considerations for ACMV systems often lead the design team to consider mocking up a typical space. This allows the team and users to better understand the impact of design decisions, develop application-specific solutions and experiment with exceptional conditions.

Products

Passive Thermosiphon Beams

Mechanical design

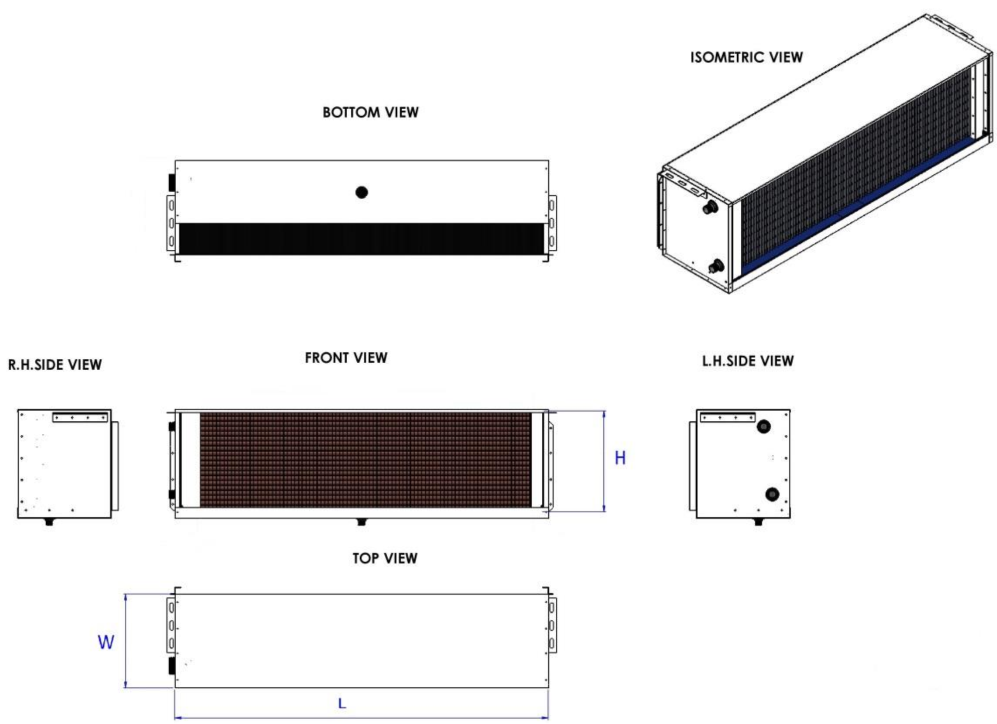


Figure 6 PTB structure diagram

Table 1 PTB nominal dimensions

Code	Length L (mm)	Height H (mm)	Width W (mm)	Outlet width A (mm)	Dry weight (Kg)
1200L	1200	220	300	75	11

1200N	1200	350	300	100	18
1200H	1200	510	300	135	26

Materials

- The casing is constructed with 2 mm galvanized steel and 3 mm aluminum dedicated for top and bottom panels and powder coated (white RAL 9010 or a standard color from the RAL range). It is strictly sealed to prevent air leakage before delivery.
- The cooling coil is constructed with 1/2" copper pipes and aluminum fins with thickness of 0.15 mm. It is factory leak tested with a burst pressure rating of 130 bar at 50 ˚C.
- The frame and mounting brackets are constructed with 3 mm galvanized steel.
- The condensation tray is made of 1mm galvanized steel.
- The 3 mm insulator is attached on internal surfaces of the casing and external surfaces of the condensation tray.
- The detachable induction grille is constructed with perforated aluminium or galvanized steel for better stability.

Construction features

- Ø3/4" water connection with plain end or with threaded connector.
- Ø1/2" drainage connector is mounted on the condensation tray at the side or at bottom center.

Active thermosiphon beams

Mechanical design

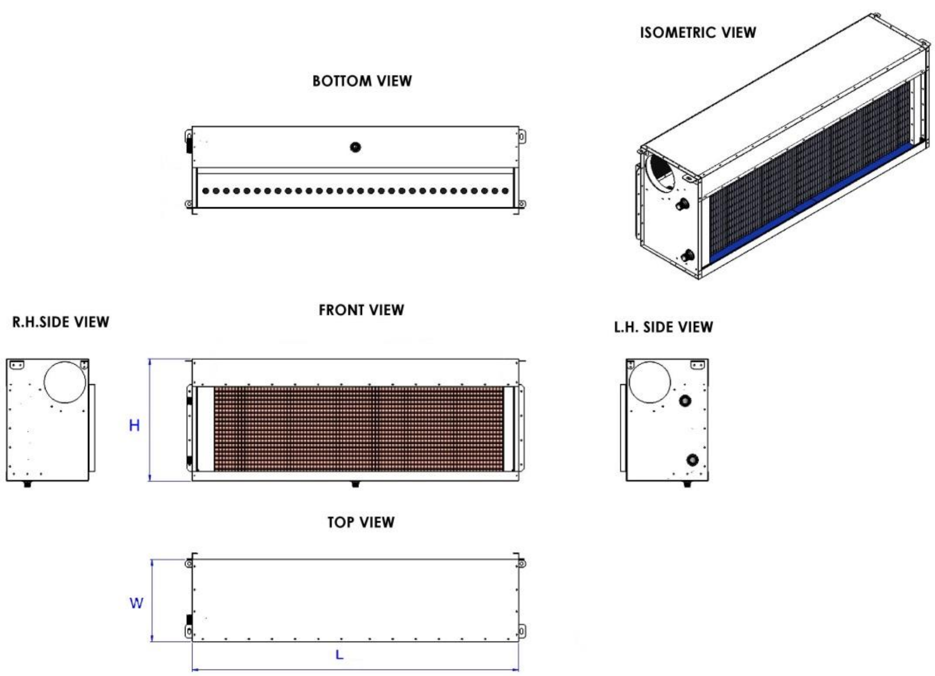


Figure 7 ATB structure diagram

Table 2 ATB nominal dimensions

Code	Length L (mm)	Height H (mm)	Width W (mm)	Outlet width A (mm)	Dry weight (Kg)
1200L	1200	350	300	75	15
1200N	1200	450	300	100	24
1200H	1200	650	300	135	32

Materials

- The casing is constructed with 1 mm galvanized steel and powder coated (white RAL 9010 or a standard color from the RAL range). It is strictly sealed to prevent air leakage before delivery.
- The cooling coil is constructed with 1/2" copper pipes and aluminum fins with thickness of 0.15 mm. It is factory leak tested with a burst pressure rating of 130 bar at 50 ˚C.
- The frame and mounting brackets are constructed with 2 mm galvanized steel.
- The condensation tray is made of 1mm galvanized steel.
- The 3 mm insulator is attached on internal surfaces of the casing and external surfaces of the condensation tray.
- The induction nozzles are made of fire resistant material and are press fitted into the casing.
- The detachable induction grille is constructed with perforated aluminium or galvanized steel for better stability.

Construction features

- Ø150 mm round spigot with left and right hand primary air connections.
- Ø3/4" water connection with plain end or with threaded connector.
- Ø1/2" drainage connector is mounted on the condensation tray at the side or at bottom center.

Order Details

Product code

AAA-BBBB-C-D-EE-FF-GG

AAA (Terminal unit):

Passive Thermosiphon Beam (PTB)

Active Thermosiphon Beam (ATB)

BBBB (Length of terminal unit):

Standard 1200 (mm)/ can be designed upon request

C (Height of terminal unit):

L/N/H

D (Nozzle side)

Inapplicable (I)

Small (S)

Middle (M)

Large (L)

EE (Mounting)

Wall Mounted (WM)

Ceiling Mounted (CM)

FF. (Water connection):

Smooth copper pipe (CP)

External thread (ET)

GG (Exposed surface)

Powder coat definition

Order example

ATB-1200-N-M-WM-ET-RAL9006

Contact Information

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Since the founding in Singapore in 2014, Air T&D LTE. LTD. has aimed to be a market leader and supplier in air treatment and distribution technology and providing energy-efficient solutions and services in Southeast Asia. We hope to act as a catalyst to build a more sustainable society and create value for our communities, partners, customers and investors alike and we sincerely hope that our products and services will benefit to you.