

CTA Bulletin

Home Theater HVAC

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Foreword

This bulletin was created by the CTA/CEDIA R10 Residential Systems Committee. This bulletin focuses on sound abatement (ingress and egress) for air handling equipment (including allowing for maximum dynamic range within the listening space) proper air exchanges and treating equipment racks and spaces to maintain adequate operating temperatures and humidity.

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1. Introduction

HVAC systems should be carefully designed to meet the special needs of the home theater room. First, the HVAC system should be properly sized to accommodate the added heat load generated by people and AV equipment. Secondly, the HVAC system should maintain a low background noise level even when operating under full load conditions. The objectives are to maintain the room's environment for:

- occupant comfort (temperature and humidity),
- safe equipment operating temperatures
- Noise-free acoustics.

Added heat loads, background noise specifications and ventilation requirements should be addressed very early with the HVAC designer/installer to ensure they are included in the design.

2. References

2.1 Informative References

1. ANSI/ASHRAE 55. (2005). *2005 ASHRAE handbook — fundamentals*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
2. ANSI/ASHRAE 55. (2007). *2007 ASHRAE handbook — HVAC applications*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
3. ASTM E477-06a, *Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers*.
4. CTA/CEDIA-CEB22. (2009). Home Theater Recommended Practice: Audio Design.
5. CRC, 1997, *Thermal Measurements In Electronics Cooling*
6. CRC, 2000, *Handbook Of Thermal Engineering*
Coyne, J.C., 1982, *An Approximate Thermal Model for Outdoor Electronics Cabinets (Bell System Technical Journal, Vol. 1, No. 2)*
7. ELLISON, G.N., 1995, *Fan Cooled Enclosure Analysis Using First Order Method*
8. SMACNA. (2004). *HVAC sound and vibration manual*. Chantilly, VA: Sheet Metal and Air Conditioning Contractors' National Association.
9. SMACNA. (2006). *HVAC Systems — Duct Design*. Chantilly, VA: Sheet Metal and Air Conditioning Contractors' National Association.
10. THE UPTIME INSTITUTE, *Changing Cooling Requirements Leave Many Data Centers at Risk*

2.2 Informative Reference Acquisition

- ASHRAE Standards
American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329; Phone: 404-636-8400; Fax: 404-321-5478; Internet: <http://www.ashrae.org>

- ASTM International Standards
100 Barr Harbor Drive, West Conshohocken, Pennsylvania, USA
Phone: (610) 832-9500 Fax: (610) 832-9555
Internet <http://www.astm.org/index.shtml>
- Consumer Technology Association (CTA)™, 1919 S. Eads St, Arlington, VA, 22202; Phone: 703-907-7600; Fax: 703-907-7675; Internet: <http://www.cta.tech>
- CEDIA, Custom Electronic Design and Installation Association, 7150 Winton Dr, Suite 300, Indianapolis, IN 46268; Phone: 317-328-4336; Fax: 317-735-4012; Internet: <http://www.cedia.net>
- CRC Industries America Group, 885 Louis Drive, Warminster, PA 18974-2869; Phone: 215-674-4300; Fax: 215-674-2196; Internet: <http://www.crcindustries.com>
- Electronics Cooling Magazine; 1000 Germantown Pike, Plymouth Meeting, PA 19462
Phone: Tel: 484-688-0300; Fax: +1 484-688-0303; Internet: <http://www.electronics-cooling.com>
- Handbook of Thermal Engineering, Frank Kreith; Publisher: CRC Press; 1 edition (December 27, 1999) ISBN-10: 084939581X, ISBN-13: 978-0849395819
- SMACNA Standards
Sheet Metal and Air Conditioning Contractor's National Association,
4201 Lafayette Center Drive, Chantilly, VA 20151-1291; Phone: 703-803-2980; Fax: 703-808-3732; Internet: <http://www.smacna.org>
- The UPTIME Institute; 20 West 37th Street, 6th floor, New York, NY 10018; Phone: 505-946-3459; Internet: <http://www.uptimeinstitute.org>
Thermal Measurements In Electronic Cooling, Edited by Kaveh Azar; CRC Press, 1st edition; ISBN-10: 0849332796, ISBN-13: 978-0849332791

3. Compliance Notation

As used in this document “should” denotes a provision that is recommended but not mandatory. “May” denotes a feature whose presence does not preclude compliance, and implementation of which is optional. “Optional” denotes items that may or may not be present in a compliant device. This document does not contain any normative elements.

4. Symbols and Abbreviations

ASHRAE – American Society of Heating, Refrigerating and Air Conditioning
BTU/H – British thermal unit per hour
CFM – Cubic feet per minute
dB(A) – decibal weighting scale
HVAC – Heating, Ventilating and Air Conditioning
MTBF – Mean Time Between Failure
NC – Noise Criteria

RC – Room Criteria

RH – Relative Humidity

SPL – Sound Pressure Level

5. Definitions

Cooling: Transfer of thermal energy

DbA – dBA weighting: sound-pressure levels derived using A-weighting denoted by "dBA," or A-weighted dB levels; standard weighting curve applied to audio measurements, designed to reflect the response of the human ear.

Dehumidifier: Equipment designed to reduce the amount of water vapor in the ambient atmosphere.

Dew Point: is the temperature at which humid air should be cooled, at constant barometric pressure, for water vapor to condense into water

Heat Removal: to provide an operating environment that allows a long equipment life and reliable operation.

Humidifier: An apparatus for supplying moisture to the air and for maintaining desired humid conditions

Passive Cooling: Use of naturally rising warmer air to remove heat.

Active Ventilation: Use of a forced-air device to remove heat, usually a fan or blower.

6. Optimal room environment

The design of a home theater can involve disciplines beyond the audio and visual elements. One of those is the performance of the HVAC (Heating, Ventilating and Air Conditioning) systems in the home theater environment. Properly designed, it will provide environmental comfort for the occupants, keep the equipment operating at a safe temperature and all will run silently so that those soft spoken scenes in the movies will not have unwanted background noise. While solutions can range from a simple cabinet exhaust fan to central heating and cooling units provided by the HVAC mechanical contractor, it should be a carefully considered part of the Home Theater design.

The purpose of this document is to provide the Home Theater designer with the requisite background knowledge and guidelines to incorporate all aspects of HVAC into the design. In some cases (i.e. cabinet ventilation, projector exhaust fans, etc.) the Home Theater designer provides most all aspects of the heat management. In other cases (i.e. occupant comfort, equipment rooms, etc.), the Home Theater designer should collaborate with those responsible

for the residence's HVAC systems. In either case, the HT designer should understand specifications and implementation methods. The following provides a summary of the key elements of the HVAC Home Theater design.

6.1 Occupant Comfort

To properly design an HVAC system to heat and cool the main theater seating area requires a close collaboration between the HVAC system designer and the theater designer. Obviously, the HVAC designer should account for the typical elements in sizing the HVAC system for any space. This can include room size, insulation, orientation to sun, local climate, windows, etc. What the HVAC designer is not likely to know (particularly in the pre-construction/bidding phase) is what additional "heat" elements result from the use of the room as a theater. Thus, it is incumbent on the theater designer to specify factors such as maximum number of occupants (typically the number of seats), heat loads for equipment in the same space as the occupants (i.e. projectors, amps, receivers, etc), and room usage/activity (watching movies, gaming, entertaining).

The optimal room environment for a home theater is one where the temperature and humidity are comfortable to all viewers. In general, the HVAC system should be able to provide a constantly maintained room temperature of 20°C – 23.9°C (68°F - 75°F) and a relative humidity of 30% - 60%. There should be enough air exchanges per hour to ensure that the amount of heat produced by occupants and the electronic heat load are properly ventilated and do not significantly raise the room temperature or humidity. A good rule of thumb is to design the system based on the conditions above in relation to the maximum room occupancy plus one, which allows for system overhead.

6.2 Relative Humidity

Relative humidity (RH) is the ratio of moisture present in the air to the amount of moisture the air can hold at saturation, expressed as a percentage. Thus, when air is fully saturated it is at a relative humidity of 100%. Since air expands when heated and contracts when cooled (while the "grains" of moisture generally stay the same), RH is fully dependent on temperature. Thus, as temperature increases then humidity decreases. Similarly, as temperature decreases then humidity increases – at least until we reach saturation or the dew point.

Temperature differences due to climate, geographical region and season can influence what is an acceptable equipment humidity operating range. For example, in a northern climate in winter at 0°F, 25% humidity is perfectly acceptable. However, in summer, 40% at 90°F is the higher end for acceptable RH. While these extremes apply for equipment operating in an outdoor environment, home theater equipment would be in a climate controlled

environment. Under these conditions (68°-75°F), the operating relative humidity should be between 30%-60%.

Humidity in a room or area can play an important role in equipment preservation and operation. Ultimately, there are two critical areas to address: dryness and dew point. Let the air get too dry and there is the possibility of creating electrostatic build up that – when discharged – could cause harm to sensitive electronics. If a room dips below the dew point, then condensation may collect on the equipment. This can occur when cold air is quickly forced into a room with high humidity (i.e. areas with water features, indoor pools/spa, bathrooms). Equipment operating in this high moisture environment could have problems ranging from erratic operation to complete failure.

Managing the relative humidity of a room and/or equipment room can be a delicate balancing act. The room should neither be too dry or too moist. For rooms with dryness problems, a humidifier may be used to add moisture to the air. Typically, a properly operating area air conditioning (e.g., refrigeration) system will reduce the humidity to within acceptable levels. If needed, a separate dehumidifier unit may be used to augment the AC system and remove excessive moisture. Either device should be connected to a humidistat that monitors and controls the RH within the environment.

Human comfort experiments have shown that there is no lower or upper threshold where humidity starts to outweigh other thermal factors. In the comfort zone (when one is not sweating for thermoregulation), humidity has a minimal effect on overall body heat balance and comfort.

6.2.1 Temperature

The temperature of all equipment should be operated in a condition that is as close to the manufacturer's ambient temperature specifications. The recommended maximum equipment operating environment is 29.4°C (85°F). The maximum ambient temperature measured at the air inlet should be ≤ 75°F.

6.3 Background Noise

Background noise from HVAC systems should be managed. One should work closely with the HVAC engineer and/or contractor to make sure the design of the HVAC system considers all the factors of the theater design. For critical listening environments, the HVAC contractor should design and install a system with an RC (N) of <25, as stated in (ASHRAE Fundamentals 2001).

6.4 HVAC Players

In many cases a residential HVAC contractor may not be aware of, or ever completed an installation where the HVAC noise levels are considered so critical. It is important to stress to the client and other stake holders (such as an architect, general contractor, mechanical engineer, mechanical contractor, controls contractor, acoustic engineer etc.) the importance of installing a system which meets all of the design criteria.

In many circumstances, a system which is designed to deliver a maximum dynamic range acoustically within the room will require the supervision of an acoustic engineer or mechanical engineer. Once the system is installed, the electronic system contractor, or through an acoustical engineering consultant, should verify that the HVAC systems design criteria are met.

The electronic system contractor should keep a copy of the HVAC system design and all testing results and give a copy to the client upon project completion. These documents should include any as-built documents, red-line drawings, and signed change orders.

7. Heat Management in Equipment Racks and Rooms

7.1 The Need for Heat Management

To help ensure that a client's equipment meets expected lifespan, removal of heat (ventilation) from the equipment room, cabinet or rack is critical. While proper ventilation cannot guarantee that a device will last for many years (due to many variables such as mechanical failure, surges/spikes, circuit board malfunction etc), not properly ventilating equipment can almost completely ensure shortening the lifespan of a device. In order to properly ventilate the heat buildup from electronic equipment, one should calculate the heat output of the devices within the system.

Unfortunately, the calculation of heat generation is not as straight forward as one would like, due to the efficiency of each unit. The simple calculation is based on the fact that one ampere operating at 117 volts is equal to 400 BTU/H. Thus, a receiver that draws 2.5 amps outputs 1000 BTU/H.

Ironically, the simple case is not reality, as devices do not typically draw the amount of current as stated on the nameplate. In fact, many times, the nameplate rating is 4 times the actual heat output of the device. Thus, one who designs a system based off of nameplate rating in amps times 400 BTU/h will significantly oversize the amount of exhaust needed, and thus have an inefficient system design. It is also important to note that oversizing of the