BTU Ratings
Get Educated!

A Bus Air Conditioning
Informational Bulletin by

Trans/Air
School & Commercial Bus Climate Control
Design | Manufacture | Install | Service
Aside from the technical definition of the British Thermal Unit (BTU), bus air conditioning system capacity is dependent upon many variables and requires that specific rating conditions be defined!
The same system can have a higher capacity label than another system and actually have lower “real” capacity and performance

Don’t compare Apples to Oranges!

** Level the playing field **

1. Reference a performance pull-down test
2. Require BTU/hr system capacities in either the IMACA or SAE format

IMACA (International Mobile Air Conditioning Association) - Bankrupt
- Generally higher capacity ratings
- Used in the School, Mid-Sized and Cutaway bus markets
- Rating conditions are more liberal showing higher capacity

SAE (Society of Automotive Engineers)
- More conservative with lower capacity ratings
- More realistic
- Customers in Transit market more accepting of this standard
- Rating conditions are more conservative showing lower capacity given the same system
System BTU Capacity Consideration

Is the system capacity represented as Gross BTU/hr or Net BTU/hr?

- **Gross Capacity** *(most typically used)*
  Uses the weakest link (lowest capacity) among the evaporator, condenser, and compressor to determine overall system capacity

- **Net Capacity** *(rarely used and difficult to measure)*
  Uses multiple simultaneous equations until the system is balanced
Calculating GROSS System BTU Capacity (IMACA)

Collect Primary Component BTU/hr Capacities

Evaporators – BTU/hr as listed by manufacturer using IMACA
Condensers – BTU/hr as listed by manufacturer using IMACA
Compressors – Current industry practice / guidelines
  - 10 cid = 53,000 BTU/hr (7.5 Horsepower)
  - 13 cid = 60,000 BTU/hr (10.2 Horsepower)
  - 20 cid = 80,000 BTU/hr (10.2 Horsepower)
  - 25-40 cid = 140,000 BTU/hr (21.2 Horsepower)
    (this category often switches to the more conservative standards)

Factory Dash Air Systems –
  - Ford or GM Small Cutaway ~15,000 - 18,000 BTU/hr a/c
  - International or Freightliner Mid-Sized Cutaway ~25,000 BTU/HR a/c
  - Rail Chassis Front or Rear Engine ~20,000 – 40,000 BTU/hr a/c
    (depends on manufacturer/supplier)

Calculation Steps

- **Step 1**: Add together all the system evaporator capacities
- **Step 2**: Add together all the system condenser capacities and then subtract a factor that accounts for heat generated by the compressor (Compressor Horsepower x 2500)
- **Step 3**: Add together all the system compressor capacities
- **Step 4**: Compare Capacity Totals from Steps 1, 2, and 3…

**Total Gross System Capacity is the lowest of the three totals**
Each system component has its own capacity and capacity labels can change, higher or lower, depending on the rating conditions being used.

- **Evaporator** (inside passenger compartment) has the capacity to absorb heat from the air passing through it, thus reducing temperature and removing humidity.
- **Condenser** (outside passenger/driver compartment) has the capacity to reject the heat to the air passing through it that was absorbed by the evaporator and generated from the compressor.
- **Compressor** (on vehicle engine) pumps medium (refrigerant) through a system via hoses to the evaporator and condenser so heat can be transferred.

When components are configured together as a system in a vehicle, the system has a rated GROSS capacity.

Air conditioning system manufacturers may represent total system capacity differently.

“Tricks” can be played by only mentioning evaporator capacity without consideration for the weakest link among the three major system components.
**Example: 126K BTU/hr System?**

<table>
<thead>
<tr>
<th>Step</th>
<th>System Component</th>
<th>Listed (K)</th>
<th>IMACA (K)</th>
<th>SAE (K)</th>
<th>System Component</th>
<th>Listed (K)</th>
<th>IMACA (K)</th>
<th>SAE (K)</th>
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<tbody>
<tr>
<td>1</td>
<td>FM55 Front</td>
<td>55</td>
<td>65</td>
<td>40</td>
<td>Front</td>
<td>50</td>
<td>55</td>
<td>38</td>
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<tr>
<td></td>
<td>FM55 Rear</td>
<td>55</td>
<td>65</td>
<td>40</td>
<td>Rear</td>
<td>50</td>
<td>55</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>27K Dash</td>
<td>27</td>
<td>43</td>
<td>26</td>
<td>Dash</td>
<td>26</td>
<td>25</td>
<td>11</td>
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<tr>
<td></td>
<td><strong>Evaporator Total</strong></td>
<td>137</td>
<td>173</td>
<td>106</td>
<td><strong>Evaporator Total</strong></td>
<td>126</td>
<td>135</td>
<td>87</td>
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<tr>
<td>2</td>
<td>SMC3L Skirt</td>
<td>76</td>
<td>87</td>
<td>71</td>
<td>FRC</td>
<td>35</td>
<td>53</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>SMC3L Skirt</td>
<td>76</td>
<td>87</td>
<td>71</td>
<td>Under Body</td>
<td>60</td>
<td>53</td>
<td>44</td>
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<tr>
<td></td>
<td><strong>Condenser Total</strong></td>
<td>133</td>
<td>155</td>
<td>123</td>
<td><strong>Condenser Total</strong></td>
<td>76</td>
<td>87</td>
<td>59</td>
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<tr>
<td>3</td>
<td>(1) 10 CID</td>
<td>60</td>
<td>60</td>
<td>39</td>
<td>(1) 10 CID</td>
<td>60</td>
<td>60</td>
<td>39</td>
</tr>
<tr>
<td></td>
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<td>(1) 10 CID</td>
<td>60</td>
<td>60</td>
<td>39</td>
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<tr>
<td></td>
<td><strong>Compressor Total</strong></td>
<td>120</td>
<td>120</td>
<td>78</td>
<td><strong>Compressor Total</strong></td>
<td>120</td>
<td>120</td>
<td>78</td>
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<tr>
<td>4</td>
<td><strong>Calculated System Capacity</strong></td>
<td>120</td>
<td>120</td>
<td>78</td>
<td><strong>Calculated System Capacity</strong></td>
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<td>59</td>
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<td></td>
<td>Advertised System Capacity</td>
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<td></td>
<td></td>
<td>Advertised System Capacity</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Listed System Capacity</td>
<td>120</td>
<td></td>
<td></td>
<td>Listed System Capacity</td>
<td>126</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**No Chain Is Stronger Than It’s Weakest Link!**
To be sure, the best and most important evaluation of a system is to measure the ability of the installed system to cool a bus in a “Hot Box” (Paint Booth) from a starting temperature to 70°F in a 30 minute time period, at a set engine RPM

The ability to cool the vehicle in a 30 minute test is the most valid indicator of how the bus will cool in your applications

To upgrade your system to a higher performance requirement, increase the start/soak temperature

No matter what segment of the bus industry you are in, there is an association that has a performance specification / test developed in cooperation with the air conditioning companies
### Performance Comparison Example

**BTU/hr Label vs. 30 Minute 100° Hot Box Cool Down Test**

<table>
<thead>
<tr>
<th>Bus Length</th>
<th>Trans/Air</th>
<th>Competitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.7 ft</td>
<td>60K</td>
<td>80K</td>
</tr>
<tr>
<td></td>
<td>76°</td>
<td>80°</td>
</tr>
<tr>
<td>33.5 ft</td>
<td>120K</td>
<td>126K</td>
</tr>
<tr>
<td></td>
<td>71°</td>
<td>75°</td>
</tr>
</tbody>
</table>

Listed or advertised BTU/hr labels can be misleading.

Even though Trans/Air listed both systems at a lower BTU/hr, they actually performed better than the competitive systems.
Heat soak the vehicle for a minimum of 2 hours to 100°F, and reduce the interior temperature to 70°F +/- 3°F in 30 minutes or less

A minimum relative humidity of 50% shall be maintained in the hot box

Have the engine at high idle to the engine/chassis manufacturers recommended RPM’s for the duration of test

Utilize 2 external and 4 internal thermocouples to verify temperatures readings

Some regions / properties that have their own unique tests and specifications guidelines:

- Florida DOT
- NJ Transit
- RTC / Las Vegas
- Houston Metro

Other regions / properties utilize existing tests and specification guidelines that are broken down by vehicle type; School Bus, Commercial Bus, Transit Bus, and Motor Coach (Motor Coach can any of the performance specifications that follow).
DO NOT use BTU Labels as your primary criteria for evaluating or comparing bus air conditioning systems unless:

1. You know the rating conditions used
2. The “weakest link” (Gross) calculation method was used
3. You have guaranteed performance pull-down compliance

Theoretical BTU/hr system ratings, when using realistic rating conditions at the various vehicle engine/compressor speeds, is a valuable piece of information to assess the application of the system to the vehicle.

HOWEVER, the best way to measure performance is to install an air conditioning system in the target vehicle, put the target vehicle into an environmental chamber, and do a standardized performance pull-down test…
Pull-Down Test Guidelines & Specifications

School Bus

National Congress of School Transportation

- **Standard Performance** – The installed air conditioning system should cool the interior of the bus from 100 degrees Fahrenheit to 80 degrees Fahrenheit in 30 minutes...

- **High Performance** - The installed air conditioning system should cool the interior of the bus from 100 degrees Fahrenheit to 70 degrees Fahrenheit in 30 minutes...

Website Link to Full 2010 NCST Guidelines

Pull-Down Test Guidelines & Specifications

Commercial Bus

Mid-Sized Bus Manufacturers Association

- **Northern Climate Minimum Performance** – The air conditioning system shall lower the internal temperature of the vehicle at the thermocouple locations to a maximum, average temperature of 70°F DB in 30 minutes or less of the start from a minimum ambient starting temperature of 90°F DB...

- **Southern Climate Minimum Performance** – The air conditioning system shall lower the internal temperature of the vehicle at the thermocouple locations to a maximum, average temperature of 70°F DB in 30 minutes or less of the start from a minimum ambient starting temperature of 100°F DB...

Website Link to Full MSBMA Guidelines

http://www.ntea.com/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=12470
Transit Bus

- **Capacity and Performance Requirements** – The air-conditioning portion of the HVAC system shall be capable of reducing the passenger compartment temperature from 115°F to 95°F in less than 20 minutes after engine start-up...

- **Hotter Ambient Conditions** – The air conditioning portion of the HVAC system shall be capable of reducing the passenger compartment temperature from 110°F to 70°F +/- 3°F in less than 30 minutes after system engagement for 30, 35, and 40-foot buses...

Website Link to Full APTA Guidelines

Basics of Bus Air Conditioning

Refrigeration Cycle

Evaporator (Inside the Vehicle) Absorbs Heat / By Change of State from Liquid to Gas

Compressor (Mounted on the Engine) Pumps Refrigerant

Condenser (Outside the Vehicle) Rejects Heat / By Change of State from Gas to Liquid

Expansion Valve (Inside the Evaporator) Meters Refrigerant

Suction Line Low Pressure Gas (Cool)

Discharge Line High Pressure Gas (Hot)

Liquid Line Warm Liquid

Sight Glass (On the Filter Drier) Allows For Visual Inspection of Moisture Level

Filter Drier (Inside the Condenser) Removes Moisture and Impurities From Refrigerant

System Operation
Trans/Air Manufacturing Corporation is an ISO 9001 registered firm, manufacturing a full line of climate control systems for the school, commercial and electric/hybrid vehicle markets. Units, parts, service, training, warranty, and new or aftermarket installations are available through factory-owned operations or a network of distributors throughout North America.

To obtain more information regarding BTU ratings or any of Trans/Air’s products and services, please visit our website at www.transairmfg.com or contact us directly at:

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