“Managing Airflow in Zoned Applications”

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This article explains why a bypass duct does not always work as expected. We will learn the importance of creating sufficient resistance to flow *(pressure drop)* across the bypass duct. This article will also provide a simple method to correctly balance the bypass duct in the field, so that it will work as expected and will not adversely affect HVAC system performance.

In Illustration #1, a typical bypass duct arrangement is shown. In this case a 5-ton HVAC system at a nominal 2000 Cfm is split into 2 zones. For the sake of simplicity, the zones are assumed to be equal in load at 1000 Cfm each. ACCA Manual Zr defines this ratio of *bypass Cfm* versus *system Cfm* as the “*Bypass Factor*” *(BPF)* = 1000 / 2000 = .50 or 50%.

According to most zone manufacturer's catalog selections, a 12” round bypass duct *(or equivalent rectangular duct)* would be specified to move 1000 Cfm, resulting in a bypass velocity of 1300fpm. In their guidance, no additional airflow management tools are utilized other than the bypass.

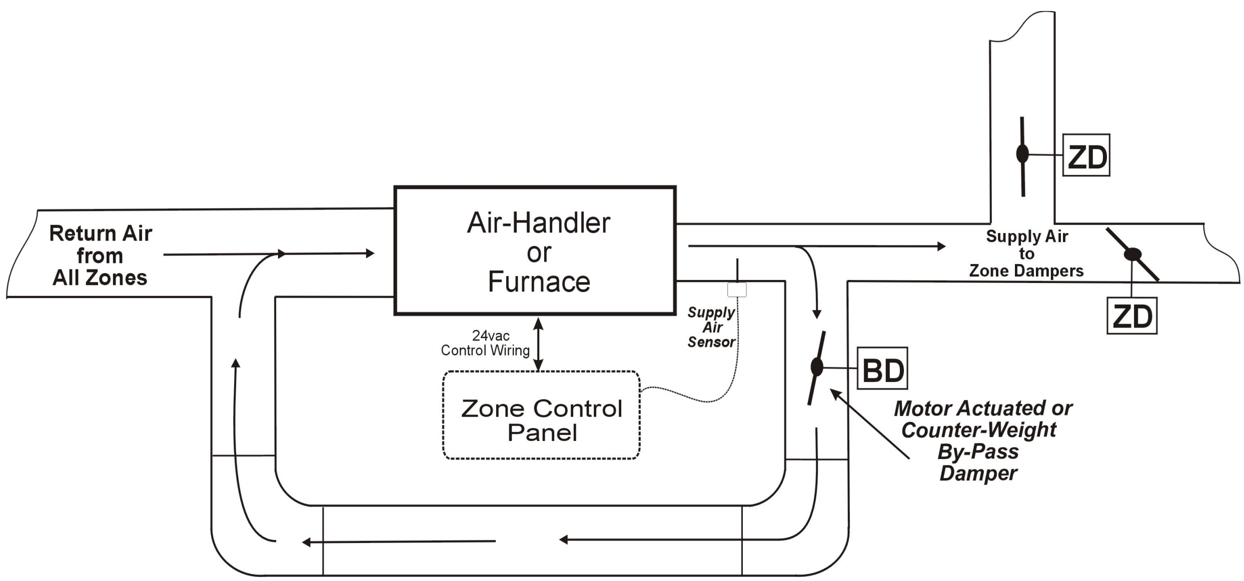


Illustration 1: Old Bypass Configuration

Regardless of the orientation of the system air-handler or furnace (up-flow, down-flow or horizontal) it is obvious that the bypass duct would include a single take-off from the supply plenum, the bypass damper itself, a single 90° elbow, perhaps 8 – 10 feet of straight 12” diameter pipe, another 90° elbow, and finally another take-off back into the return plenum. Looks fine right? The problem with this bypass duct is that it is simply to short! It does not equal the *theoretical equivalent length (TEL)* of the ducts used in either Zone 1 or Zone 2.

TEL is the sum of the straight linear feet of duct plus all the angled fittings *(including dampers)* that exist on a particular duct run. Each duct run *(zone)* is considered to be a path with supply and return duct losses included in the calculation. The longer the TEL the more pressure drop *(Delta P)* encountered, thus the air encounters more resistance to flow. Guidance on determining TEL, pressure drops, and duct sizing can be found in ACCA Manual D.

Imagine that the Zone 1 path has a TEL of 175 feet and that the Zone 2 path has a TEL of 185 feet … but the bypass duct path has a TEL of only 70ft. Which way do you think the air will travel if Zone 1 or Zone 2 closes down and the bypass damper opens up? Just like electricity, the air will move down the path of least resistance, which is the easiest and/or shortest distance to travel.

This is the primary reason that a bypass duct & damper assembly does not always work as it is expected to work. The 12" diameter bypass duct that was supposed to move 1000 Cfm during bypass mode, actually allows much more airflow *(Cfm)*. *Why?* Because, just like a short in an electrical circuit that drains off all of the power, the bypass duct becomes the path of least resistance. Thus, it is easier for the air to take a shortcut back through the bypass duct than it is for the air to flow down the longer active duct run.

This short circuiting results in the active zone not receiving the volume of air it requires and the bypass duct receiving much more air than it was supposed to receive. In addition, the return air draw from the occupied space is reduced because the blower is getting much of the air it needs from the bypass duct.

As a result of the above, the air handler's total static pressure is affected. When that happens, the heating temperature rise or cooling temperature drop *(Delta T)* across the air handler is also affected. This has implications on equipment performance such as over-heating a furnace or DX coil freeze-up.

Given some thought, the Manual Zr solution becomes obvious. Create sufficient Delta P (pressure drop) across the bypass duct to avoid adversely affecting the HVAC system Delta T (differential temperature). Simply stated, when you design the bypass duct to have the same pressure drop as the longest zone run, the bypass duct will not become the path of least resistance.

The easiest and most effective way to achieve the required Delta P in the field is to install a manually adjusted volume control damper into the bypass duct. Some contractors call this a "*hand damper"* because they are typically installed on branch runs and used to manually balance airflow on a reducing type or manifold type plenum. So, just as a *hand damper* is used to balance or limit airflow on branch runs, a hand damper achieves volume control and creates pressure drop *(resistance to airflow, TEL)* across the bypass duct.

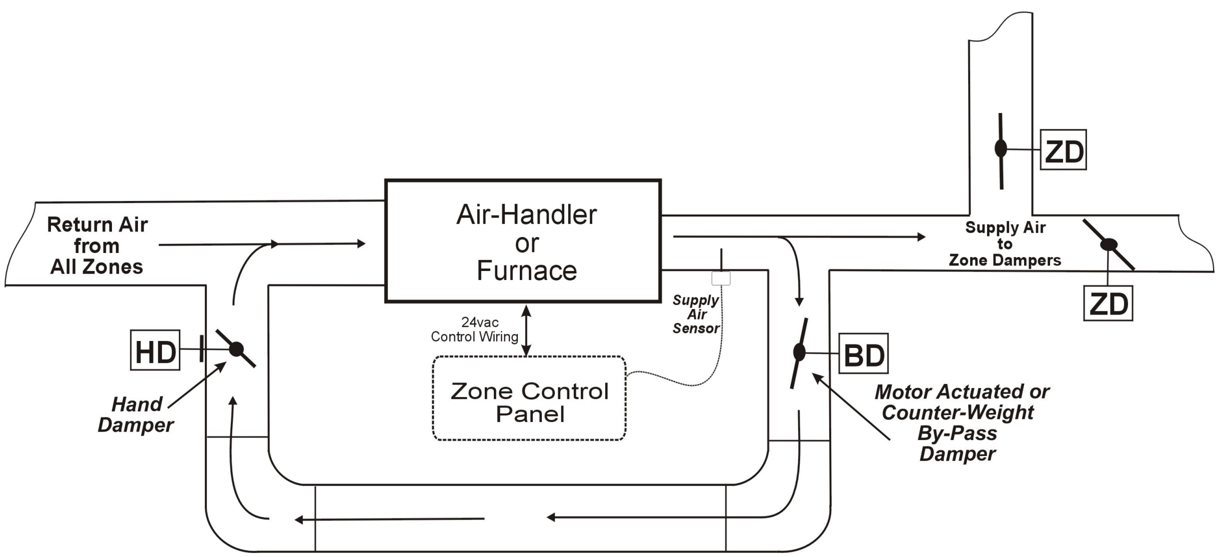


Illustration 2: New Bypass Configuration

In Illustration #2, the volume control hand damper has been installed. The actual location of the hand damper is not important. It can be placed either in front of or after the actual regulating bypass damper. What is important, is to make sure you install the hand damper somewhere in the bypass duct and that you manually adjust it (while the regulating bypass damper is wide open) to achieve the correct pressure drop across the bypass duct.

The hand damper performs a vital function that a typical regulating bypass damper cannot do. In the past, it was thought that a regulating *(counter-weight)* bypass damper created enough pressure drop across the bypass duct, in addition to regulating the return airflow. It turns out this is not the case: a typical bypass damper cannot regulate system duct pressure and create the correct pressure drop across the bypass at the same time.

A modulating *(electronic)* bypass damper can be adjusted so that *some* of its throttling range may compensate for the low bypass pressure drop, but it is not a complete solution. No matter what type of regulating bypass damper is selected, as zone dampers open and close, and the duct-work resistance changes dynamically, it results in the bypass duct becoming the path of least resistance. The solution is to make sure sufficient pressure drop has been created across the bypass duct for the worst case scenario.

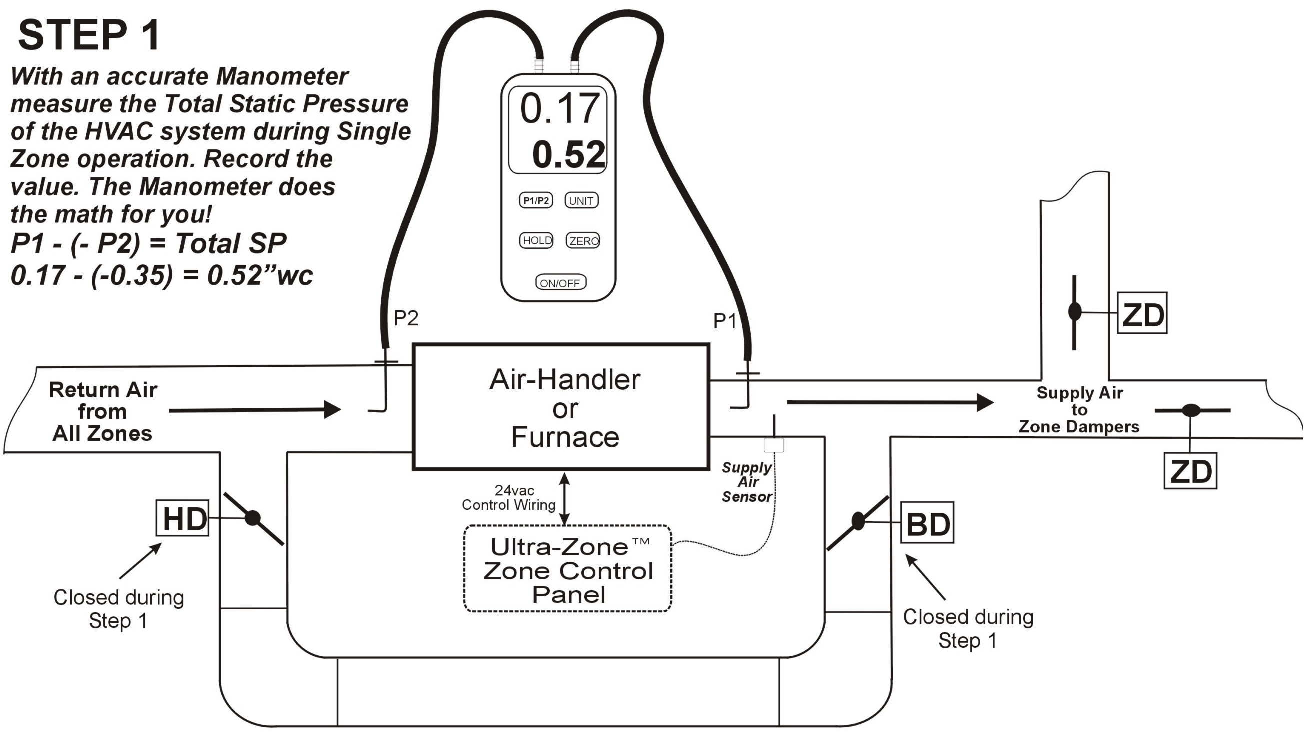
Now we will review a very simple way to setup the bypass duct pressure drop just by measuring the Total Static Pressure across the air handler or furnace. See Step #1 & Step #2 below, to easily balance the bypass duct.

STEP 1

With an accurate Manometer measure the Total Static Pressure of the HVAC system during Single Zone operation. Record the value. The Manometer does the math for you!

P1 - (- P2) = Total SP

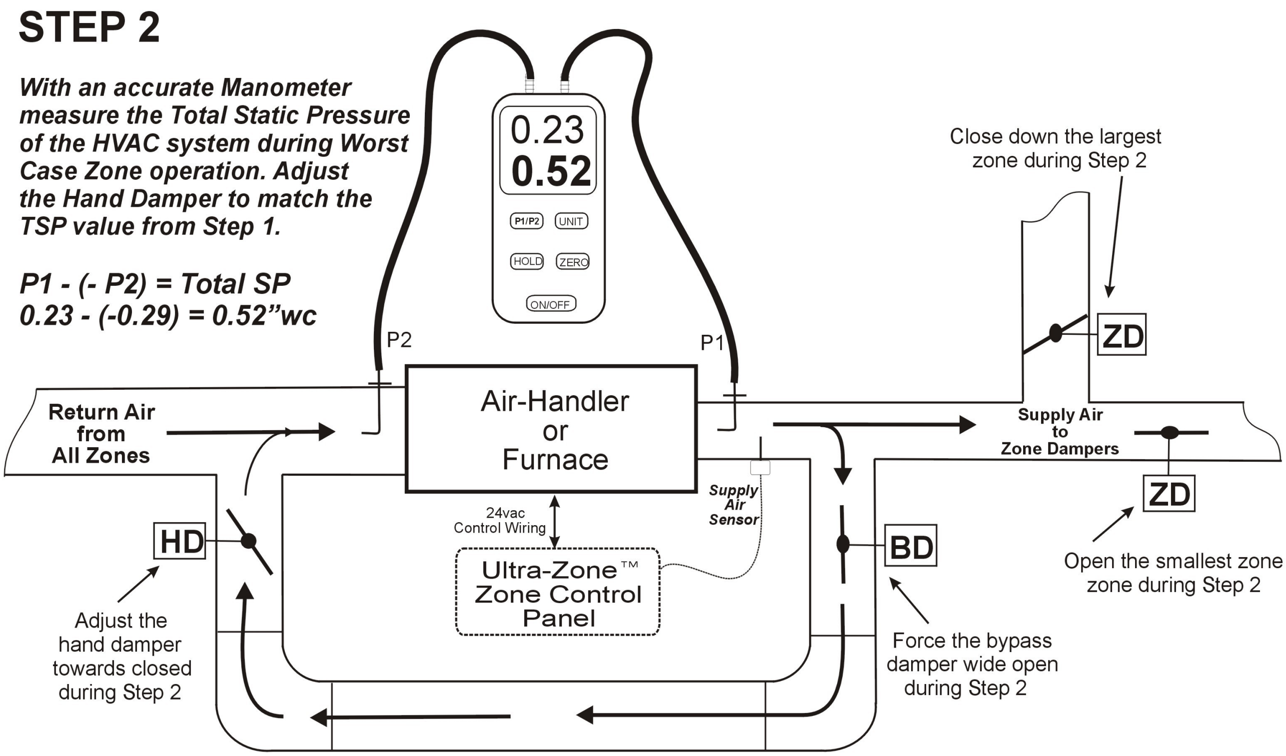
0.17 - (-0.35) = 0.52"wc



SINGLE ZONE OPERATION:

All zone dampers are open and the bypass damper(s) are closed. *Make sure the HVAC system is operating in highest Cfm mode and the air filter is new or clean.*

In this example the System Total Static Pressure is 0.52"wc. *Which becomes the target to match when adjusting the hand damper in the next step.*



MULTI - ZONE (Worst Case) OPERATION:
All zone dampers are closed except the smallest zone. The regulating bypass damper is forced wide open and the Hand damper is also open. *Make sure the HVAC system is still operating in highest Cfm mode, then adjust the hand damper (towards the closed position) and keep adjusting until the Total Static Pressure readout on the Manometer reads the same 0.52"wc target value from Step 1.*
You are finished!
Lock the Hand Damper in place, release all forced dampers and place the system in normal operation.

When you balance the bypass duct path to have the same pressure drop as the longest zone run path, then the bypass duct will not become the path of least resistance and the HVAC system's temperature rise or temperature drop (Delta T) will not be affected by excess bypass air volume.

If your zone system uses a bypass duct with a counter-weight bypass damper, spring type bypass damper or even an electronic bypass damper that does not reference total system external static pressure, then you *must* install a volume control hand damper. Even if you utilize several other airflow management tools in your zone system design, it is wise to include a volume control hand damper in your bypass duct design. The simple procedure described in this article can be used to properly balance the bypass duct in the field.