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RE: Flow Results with Recommended Modifications in the Intermountain Windboxes (ASC Document L-04-ABI-16)

Dear Mr. Malone:

In the previous letter of March 3, 2004 (ASC Document L-04-ABI-14), recommended modifications to the Intermountain windboxes were specified. This letter shows how the design modifications given in that letter alter the flow in the windboxes compared to the baseline case.

The north level 1 (bottom) windbox was simulated with inlet conditions taken from the design simulation of the SA duct (presented to ABT in the letter of January 29, 2004--ASC Document L-04-ABI-07). The figures presented here may be compared directly with the figures of the baseline results, shown in Figures 11 and 19 of the letter of January 8, 2004 (ASC Document L-04-ABI-03).

The following objectives were used when designing modifications to the windboxes:

1. Minimize the ram air effect, as measured by the velocity RMS at the burner dampers.
2. Minimize the flow variation between the burners, as measured by the pressure at the burner exits.
3. Minimize the increased pressure drop due to the modifications.

Objective (1) was of primary interest, since reducing the ram air effect also generally had the side effect of balancing the burners. But reducing the ram air effect and balancing the burners tended to cause an increase in the pressure loss, so these objectives were balanced against objective (3).

Flow Plots

Figure 1 shows the air velocity in two vertical cuts through each windbox. The upper cut is at 4' from the furnace wall, and the lower cut is at 7' from the furnace wall. The cut at 4' passes through the burner inlets, which are used as the flow exits in the model (an equal flow was specified for each burner). The outer ring at each burner is where the inlet damper was located; a 50% open perforated plate was specified at that location. The cut at 7' is located at the edge of the recommended perforated plates upstream of the burners.

As can be seen in Figure 1, the perforated plate and turning vanes located near the inlets smooth out the jets emerging from the dampers and force much of the air toward the top and bottom of the windboxes. The bulk of the flow is then going around the burners rather than straight toward them. The additional porous plates in front of the burner 1 further force the flow to the top and bottom of the windboxes, in addition to forcing the flow

toward the furnace and back walls, away from the burner inlets. The flow approaching the burner dampers is now better distributed, rather than approaching primarily from the windbox inlets, as was seen in the baseline case. The V-shaped baffle behind burner 1 reduces the flow deficit on the back side of that burner.

Pressure Drop Analysis

The left side of Tables 1 lists the drop in total pressure between the windbox dampers and the individual burners for the north level 1 windbox. (This includes the pressure drop through the 50% perforated plates located at the burner inlets.) Both the baseline and design cases are listed, along with the change in pressure drop from the baseline to design. Below the pressure drops, the "Variation" gives the maximum pressure difference between the burners. The overall changes from baseline to design are highlighted.

		Baseline p (in H_2O)	Design p (in H_2O)	Increase p (in H_2O)	Baseline RMS (%)	Design RMS (%)	Decrease RMS (factor)
North Level 1	Exit 1	0.525	0.533	0.008	45.7	29.5	1.6
	Exit 2	0.506	0.531	0.025	30.7	20.6	1.5
	Exit 3	0.483	0.517	0.034	12.7	7.8	1.6
	All Exits	0.505	0.527	0.022	32.6	21.3	1.5
	Variation	0.043	0.016	-0.027			

Table 1: Pressure drop and ram air analysis for the north level 1 burners.

Two factors were found to affect the total pressure loss in the windboxes. First, if the velocity profile is highly skewed at the model inlet (i.e., where the windbox ducts branch off from the SA duct), as it was in the baseline cases, then the pressure loss is increased. Secondly, the design modifications increase the pressure loss. Each of these factors increase the pressure loss in the windboxes by roughly 0.1" H_2O. In the current case, these two factors offset each other, since the modified (less skewed) inlet velocity profiles were used along with the design modifications. The result is that the average total pressure loss in north windbox 1 due to the modifications is only 0.022" H_2O.

The pressure variation between the burners was reduced from 0.043" H_2O to 0.016" H_2O. The amount of flow variation between the burners that this represents is dependent upon the pressure drop through the burners.

Ram Air Analysis

The burner dampers were modeled 100% open, thus representing the worst case scenario. With the burner dampers less than 100% open, the flow resistance increases, evening out the flow. A 50% open perforated plate was specified at the damper location, slightly evening out the flow.

Figure 2 shows the normal and tangential velocity components at the locations of the burner dampers. The burners are numbered 1-3, with 1 being nearest the end and 3 being nearest the center (since the windbox is symmetrical, only 3 of the 6 burners are shown). The velocity RMS values at the burner dampers are also listed on the right side of Tables 1. Compared with the baseline case, the ram air effect is reduced for all the burners by a factor of 1.5.

Conclusions

With the design modifications in place, the ram air effect has been reduced relative to the baseline, the flow balance between the burners has been improved, and the total pressure loss was only slightly increased.

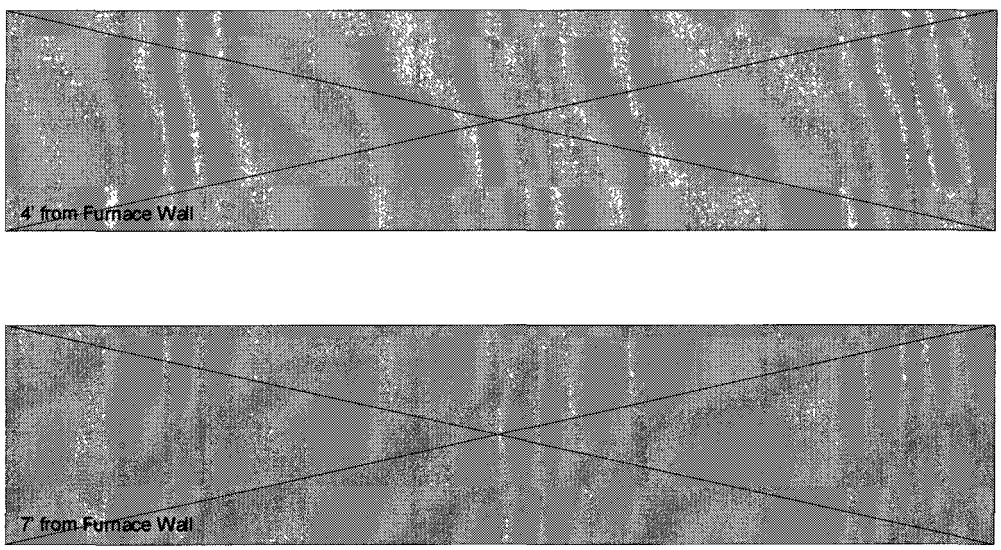
Please let me know if you have any questions about these results.

Sincerely,

Paul Harris, Ph.D.
Project Engineer

Total Velocity Magnitude - Design 7-A

North Side Level 1 - View from North



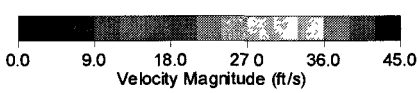


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Figure 1

Normal / Tangential Velocity at Burner Dampers - Design 7-A

North Side Level 1 - View from North

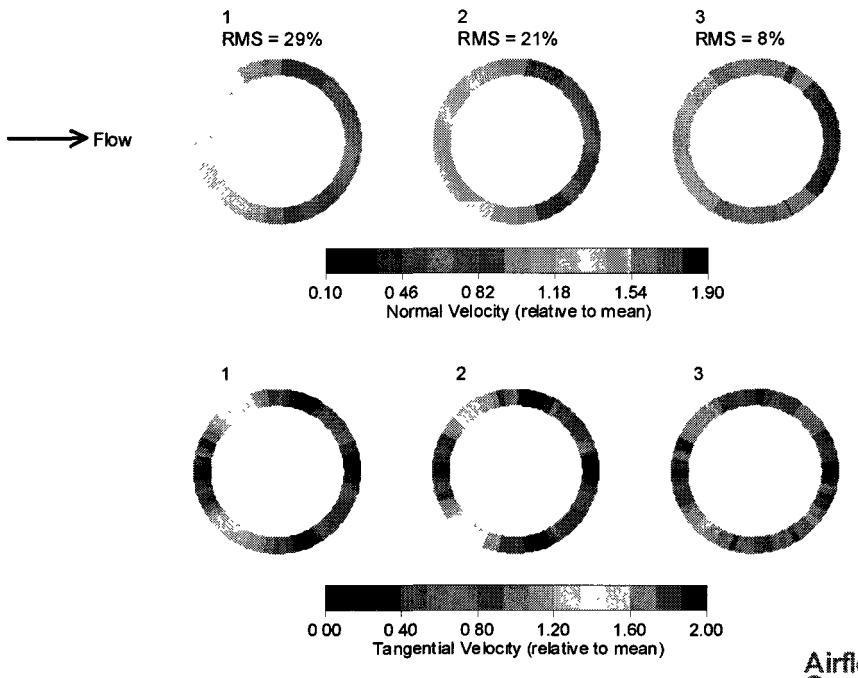

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Figure 2