FINAL REPORT ON

ELECTRIC CLOTHES DRYERS

AND LINT IGNITION CHARATERISTICS

May 2003

Appendix E
Monitor Lint Distribution – Task 3

Calculation of Backpressure for Dryer Design A with No Blockage

Even if there is no blockage of the ductwork external to the dryer vent, there will be some frictional resistance to airflow that will cause backpressure. Even a relatively smooth-walled metal duct will produce a finite amount of resistance causing backpressure. (REF1) Elbows and other junction fittings will significantly increase this resistance. (REF2) If the juncture from the fan outlet port to the duct is not completely sealed, there may be an outward flow of lint-air from the juncture. As has been seen in the case of Task 3 testing, it is possible to have lint accumulation inside the dryer chassis under conditions of zero blockage and routine cleaning of the lint screen.

The inner surface of standard four inch metal duct will lead to non-laminar flow at exhaust airspeed typical of dryers, 1000 standard feet per minute (SFM), and thus allow frictional resistance to airflow. Therefore backpressure at a point internal to the dryer chassis will exist, caused by the pressure drop along the conduit from the blower fan to the outside vent port. (REF3) The turbulent flow is a property of the fluid dynamics of the air itself and the size and geometry of the ductwork, and only secondarily an effect of the surface roughness of the inner surface of the ductwork. Therefore, even an apparently smooth duct will still have finite resistance to airflow that will increase with increased surface roughness. (REF1)

The static pressure due to resistance of the friction of the duct and the resistance to airflow of the elbow joints can be calculated using the following formula and the parameters applicable to the testing in the Task 3. Per chapter 34 of the 2001 ASHRAE Handbook (of the American Society of Heating, Refrigeration and Air Conditioning Engineers),

$$\Delta p = \sum_i \left(\frac{12\, f L_i}{D} + C_i \right) r \left(\frac{V_i}{1097} \right)^2$$

Where

ΔP is the frictional loss in terms of total pressure, in column-inches of water, that is the backpressure

D is the duct diameter, in inches. It is 4 inches for the exhaust duct in Task 3.

L_i is the length of the duct section in feet. Section 1 is the vertical section of the exhaust duct at 5 ft. Section 2 is the horizontal section of the exhaust duct at 3.5 ft.

V_i is the mean velocity of airflow, in standard feet per minute (SFM), for Dryer Design A data from Task 2 testing. In Section 1 of the exhaust duct, it was measured to be approximately 1000 SFM and in Section 2, it was estimated to be 500 SFM.

The Reynolds number is, $Re = 8.56DV = 3 \times 10^4$.

Re determines whether the flow is laminar or turbulent. Exploratory testing showed that the airflow within the exhaust duct, especially exiting the dryer is turbulent (greater than 1 x 10^4).

f is the friction factor. It is approximately 0.025 rigid metal ducting.

It is an implicit of itself, the surface roughness, the Reynolds' number (Re), diameter, velocity and viscosity of air flowing through a circular duct. It can be derived numerically using the above parameters. Alternatively, an approximate form can be used to calculate it.

$$f \cong 0.11\left(\frac{12e}{D} + \frac{68}{Re}\right)^{0.25}$$

Where the roughness factor $e \cong 0.0003$ -ft is for smooth metal ducting

The local loss coefficient for the 90-degree elbows is $C_i \cong 0.43$

The calculation yields the result

$$\Delta P \cong 0.1 \text{ inches of water}$$

The backpressure is relatively small, as is to be expected for vent ducting that is made of smooth metal with a minimum of elbow joints to redirect flow.