THE INFLUENCE OF FLUE DAMPERS

ON THE VENTING PERFORMANCE OF FLUES

A Study Prepared for

CANADA MORTGAGE AND HOUSING CORPORATION

by

Scanada Consultants Limited

Scanada Sheltair Consortium Inc.

August 13, 1987

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part V of this Act, the Government of Canada Provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has statutory responsibility to make widely available information which may be useful in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

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THE INFLUENCE OF FLUE DAMPERS ON THE VENTING PERFORMANCE OF FLUES

EXECUTIVE SUMMARY

An investigation of the effect of flue dampers on the performance of venting systems serving combustion appliances was conducted. The investigation included:

- *a literature review*
- *a review of applicable codes and standards*
- *modification of the FLUE SIMULATOR computer model to allow it to model venting systems incorporating flue dampers*
- *calibration of the modifications to FLUE SIMULATOR using data generated in field tests on a furnace/flue system incorporating a damper*
- *use of the FLUE SIMULATOR model to predict the effect of flue dampers on venting performance in a variety of situations*
- *development of guidelines for heating industry service personnel*

The chimney has three possible sources of energy to maintain draft during furnace standby - the pilot light energy, heat retained in the furnace fabric and heat retained in the chimney fabric. It was found that the principle effect of a flue damper is to restrict the chimney's access to the first two of these sources. This can make the chimney less resistant to backdrafting during standby and can prolong the duration of spillage at start-up. The magnitude of these effects depends on a number of factors:

- *There is little effect on interior chimneys since they do not require external sources of heat to maintain high standby equilibrium temperatures.*
- *The effect is greatest on light exterior chimneys since they experience high heat loss and their retained heat is low.*
- *The effect is amplified when chimneys are subject to long standby periods in cold weather, such as occur when thermostat setback is used.*

THE INFLUENCE OF FLUE DAMPERS ON THE VENTING PERFORMANCE OF FLUES

INTRODUCTION

As part of its ongoing study of combustion venting problems in Canadian houses, Canada Mortgage and Housing Corporation engaged the Scanada Sheltair Consortium to conduct studies of several aspects of chimney flue performance, including -

- the influence of thermal and flow design parameters on the performance of chimneys,

- the performance of flues shared by gas furnaces and water heaters,

- the influence of flue caps and dampers on chimney performance, and

- the performance of sealed, insulated venting systems for oil furnaces.

This report deals with one part of one of the above studies - the influence of flue dampers on flue performance. The other studies are reported on separately.

This part of the study consisted of the following tasks:

- a literature review

- a review of applicable codes and standards

- modification of FLUE SIMULATOR, a microcomputer-based model of thermal, pressure and flow interactions in the furnace/ flue/house system, to allow it to model venting systems incorporating flue dampers, and

- use of FLUE SIMULATOR in a parametric study of the effects of flue dampers.

An attempt was made to acquire for analysis any existing data from field tests of the influence of flue dampers on venting performance; but no such data was found. Therefore, as part of this project, tests were conducted on a chimney fitted with a damper.

THE INFLUENCE OF FLUE DAMPERS ON THE VENTING PERFORMANCE OF FLUES

OVERVIEW

There are currently two types of flue dampers on the market. These are:

a) electrically-activated devices
b) thermally-activated devices

Electrically-activated dampers for gas appliances were introduced in the early 1980's. They are currently approved by the Canadian Gas Association as an integral component of the furnace only; i.e. they can not be retrofitted to existing appliances. Similar electrically-activated dampers for oil furnaces were approved in 1979 by the Canadian Standards Association. These can be retrofitted to existing appliances. Both oil and gas dampers are interlocked with the main burner of the furnace and are designed to fully open instantaneously on burner turn on.

Thermally-activated vent dampers for gas appliances were only approved in 1986 by the Canadian Gas Association. These can be retrofitted to existing gas appliances. They are designed to open gradually as a function of the temperature of the flue gas.

The purpose of a damper is to minimize the loss of heat up the flue when the furnace is at standby. The origin of that heat is the heat stored in the heat exchanger at the end of the furnace operating cycle, the heat released from the pilot light (if there is one), and the heat in room air going up the flue. However, if the damper successfully prevents heat from these sources from passing through the flue at standby, then the flue loses its main source of heat at standby and will likely exhibit lower drafts at the start of the next cycle than it would if the damper were not there or were less effective.

LITERATURE REVIEW

A literature search was conducted through the Canadian Institute for Scientific and Technical Information. However, no literature dealing with the effect of flue dampers on venting performance was found.

REVIEW OF CODE REQUIREMENTS

The following codes and standards were reviewed:

Canadian Gas Association

CAN1-2.28:	Gas-Fired Appliances Equipped with Electrically Operated Automatic Vent Damper Devices Provided as Integral Components, 1981.
CAN1-6.14:	Thermally Actuated Vent Damper Devices for Use with Gas-Fired Appliances, 1986
CAN1-B149.1:	Installation Code for Natural Gas Burning Appliances and Equipment, 1978, 1980 and 1986 editions.

Canadian Standards Association

CSA.B140.14:	Automatic flue-pipe Dampers for Use with Oil-Fired Appliances, 1979

The information gleaned from this review that is relevant to this project is as follows:

Electrically-activated dampers for gas appliances

- "... the damper will be in the open position at the time the main burner is called upon to fire and at all times when it is firing."

- "The damper shall not assume its fully closed position in

less than 14 seconds from the time the main gas valve closes."

- "For an appliance equipped with a continuous pilot, the minimum free venting area of the vent gas passageway of a damper device, when in the closed position, shall not be less than either -

  a) 3.3 cm^2 or;

  b) 6.5 cm^2 per 1905 W of total continuous pilot input,

  whichever is larger."

Thermally-activated vent dampers for gas appliances

Included in the standard is a procedure for inspecting and assessing whether sufficient combustion air is available to the system, and whether such a damper device can be safely used in a particular application. As part of that procedure, a damper cannot be installed if, following a cool-down period of 15 minutes, when the furnace is turned on, spillage at the dilution device occurs for more than two minutes with all exhaust fans and fuel burning appliances operating at maximum. A copy of this procedure is included in Appendix A.

- "The minimum internal free venting area of the vent gas passageway with the damper in the closed position must be not less than 10 percent of the outlet free venting area".

- "...the device must be installed after the appliance draft hood, as close to the draft hood as practicable, and without modification of the draft hood.

Automatic Flue-Pipe Dampers for Use with Oil-Fired Appliances

- "The device shall be provided with an interlock to prevent firing of the burner of the related appliance, unless the damper is in the fully open position".

- "The device shall be constructed so that the damper will fully open and close, with no intermediate or partial opening possible".

- "The minimum internal free venting area are at any point between the inlet and the outlet of the device, with the

damper in the fully open position, shall not be less than 90 percent of the area of the flue pipe at the point of connection of the device".

- "With the damper in the closed position, the leakage past the damper shall be kept to a minimum consistent with provisions for clearances...".
- "An integral means shall be provided that will not allow the damper to commence closing in less than 2 minutes after the oil burner or the fuel oil supply, where so equipped, has been de-energized".
- The standard only recommends that the installer check for spillage once the damper is installed. It is not a mandatory part of the standard and does not specify operating exhaust fans in conjunction with the spillage test.

It appears that the safety inspection outlined in the oil standard is the predecessor of the safety inspection checklist outlined in the thermal damper standard (which does specify testing for spillage in conjunction with exhaust fans). Perhaps the vintage of the thermal damper standard (1986) reflects recent awareness of combustion venting problems in newer houses and perhaps similar safety inspections will be incorporated in the next updates for automatic dampers in oil and gas appliances.

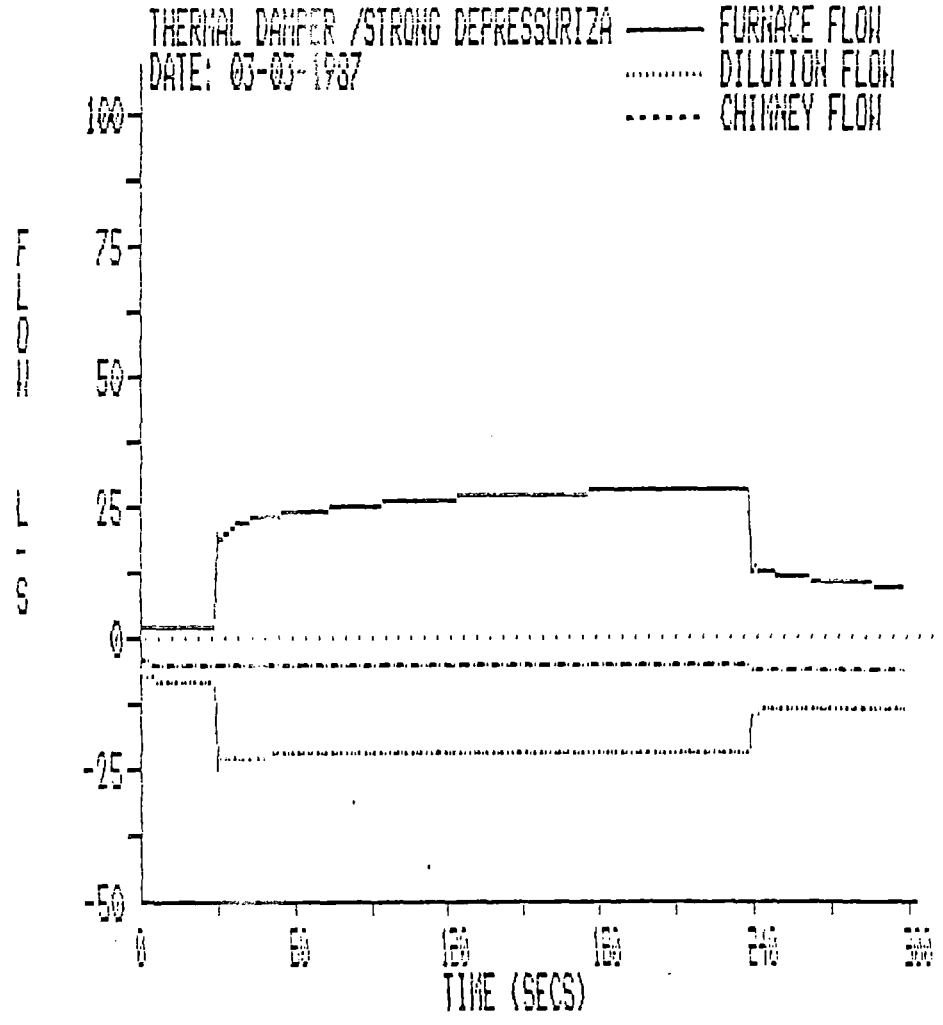
ACQUISITION AND REVIEW OF FIELD DATA

Field data was sought from the following:

- Sheltair Scientific
- Canadian Gas Association
- Canadian Combustion Research Laboratories

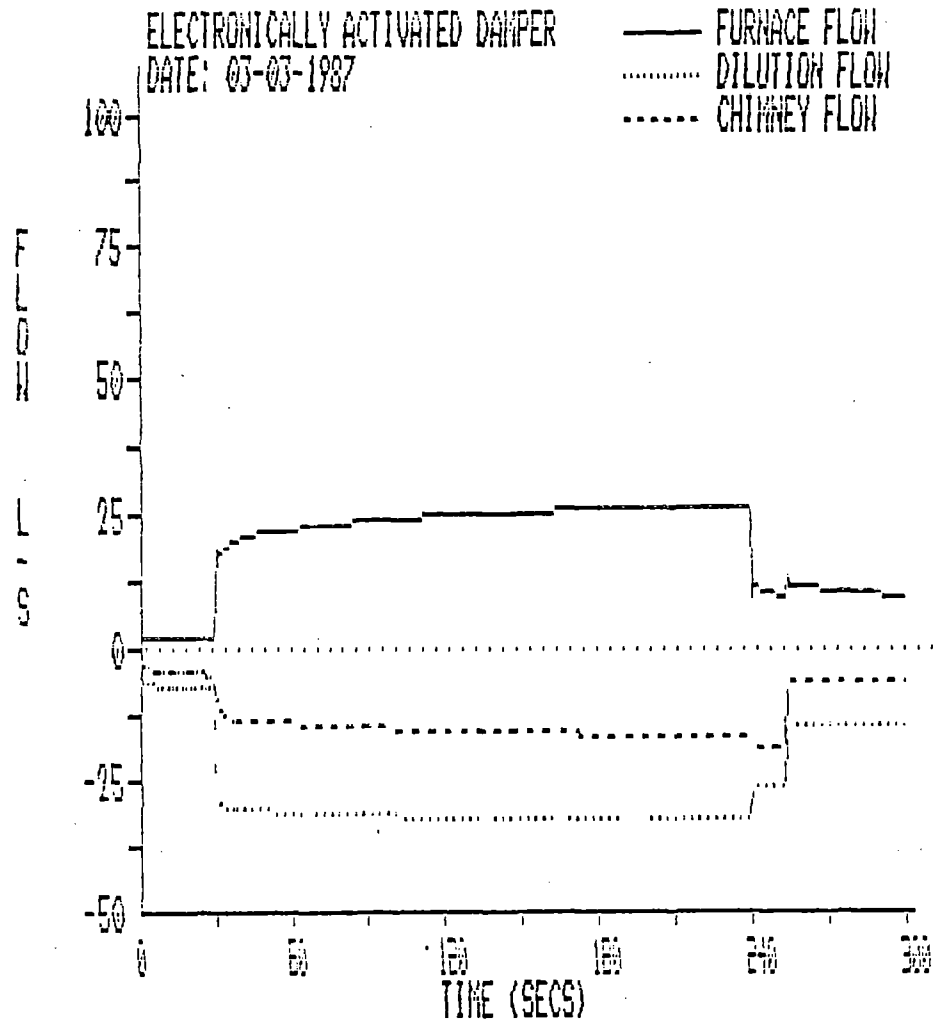
Unfortunately, none of these sources was able to provide existing data relating the performance of venting systems to the presence or absence of flue dampers.

The only data available, therefore, hardly qualifies for that name - an anecdote arose from the Chimney Safety Tests pilot workshop conducted by Sheltair Scientific Ltd. in the fall of 1986. Apparently standby backdrafting was provoked in a venting system with a thermally-activated damper. When the furnace was started, the hot combustion products were unable to reach the damper to activate it so that it would have remained closed indefinitely. A simulation of this situation has been executed using FLUE SIMULATOR, modelling both thermally- and electrically-activated dampers in a system which is subject to standby backdrafting. The results are shown in Figures 1, 2 and 3. As in the workshop, the thermal damper fails to open. However, the thermal damper's failure to open is **not a cause** of the backdrafting continuing after start-up, since the backdrafting also continues with the electrical damper. The only negative effect of the closed damper is that the downward chimney flow is restricted, thus resulting in less dilution of the combustion products spilling out the dilution port with consequently higher temperatures (approaching the combustion point of wood - Figure 3).



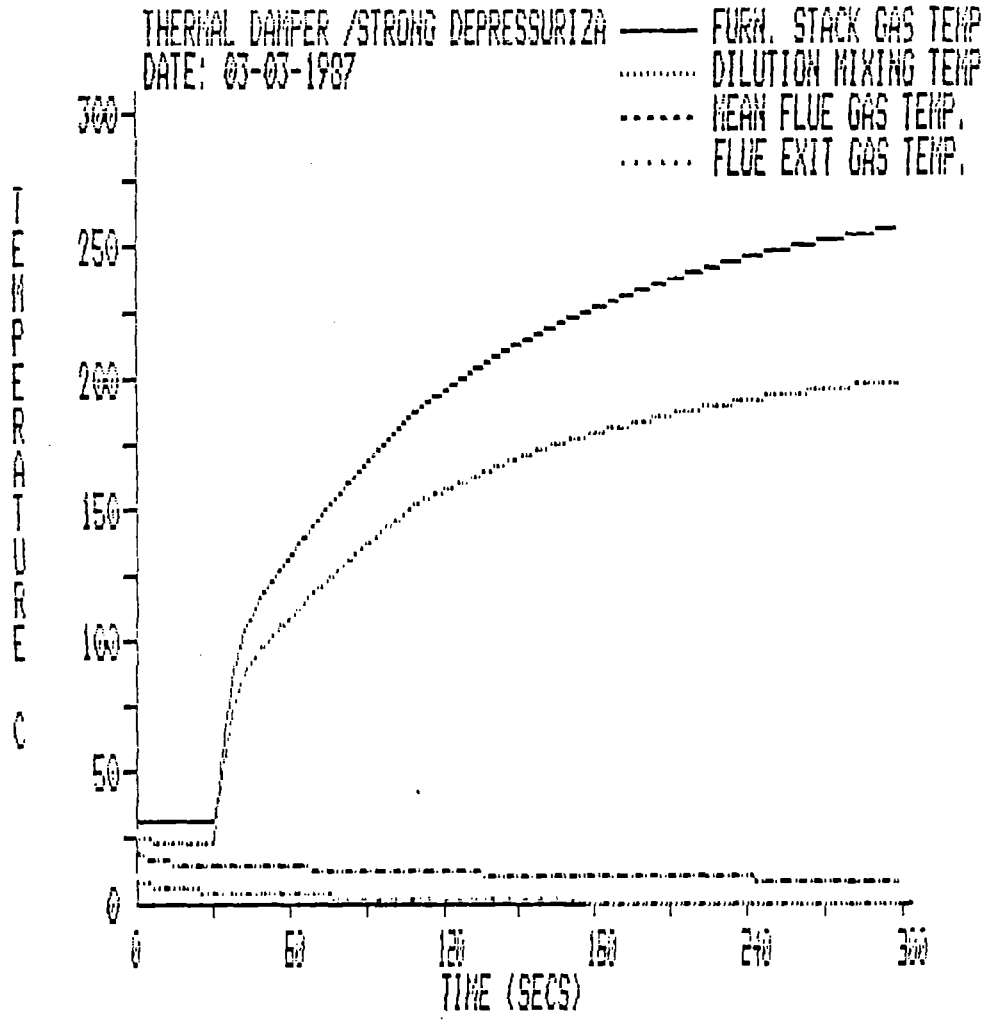
FLOW RATE vs. TIME

FIGURE 1: Flows in backdrafting venting system with thermally-activated flue damper



FLOW RATE vs. TIME

Figure 2: Flow in backdrafting venting system with electrically-activated flue damper



TEMPERATURE vs. TIME

Figure 3: Temperatures in backdrafting venting system thermally-activated flue damper

MODIFICATIONS TO FLUE SIMULATOR

FLUE SIMULATOR, a microcomputer-based model of thermal, pressure and flow interactions in the furnace/flue/house system developed for CMHC by Scanada Consultants Limited, was modified to accept the flow area of the flue damper in the closed position and the damper opening strategy (i.e. electrical or thermal) as user inputs. The flow algorithms were modified to be able to deal with the very small flue equivalent flow area* (EFA) values represented by the damper flow area. Previously a minimum flue area had been imposed to avoid division by zero errors.

For thermally activated dampers, a "ramp" of flow area vs. flue gas temperature is modelled. That is, the flow area of the thermally activated damper is a function of flue gas temperature, and, in the absence of test data, this functional relationship is assumed to be linear. This is a reasonable assumption since under normal operating conditions thermal dampers are designed to open in a matter of seconds from furnace start-up (for example, one manufacturer advertises that his product begins to modulate when the flue gas temperature reaches 120°C). Thus, for such a short time frame, a linear approximation is as good as any other relationship. The user is asked to input the temperatures below which the damper is closed (i.e. at minimum EFA) and above which it is fully open. It should be noted however, that the model does not incorporate algorithms for modelling radiative heat transfer or local convective heat transfer (two way flow) - the only mechanism in the model for the transfer of heat from the furnace heat exchanger to the damper is leakage flow past the damper. This is not expected to have a significant effect on the overall accuracy of the model's macro-predictions since these

* The equivalent flow area of a vent connector is the area of sharp-edged orifice that would pass the same flow as the vent connector at any given pressure difference.

other heat transfers are relatively small. On the other hand they may be large enough to accelerate the opening rate of the damper. Thus the model's predicted opening times for thermal dampers may be late.

COMPARISON OF FLUE SIMULATOR PREDICTIONS TO FIELD DATA

In order to test the validity of the modifications to FLUE SIMULATOR, it was used to simulate a furnace/flue system that was also tested by Sheltair Scientific Ltd. The model's predictions were compared with the field data. These comparisons are reported in detail in Appendix F.

There was quite good agreement on all parameters except the chimney exit temperature, which the model predicted to be considerably higher than was measured. This discrepancy is attributed to leakage of outside air through the chimney liner - the chimney was described by Sheltair personnel as quite old with significant spalling of liner. The model is not yet capable of modelling chimney leakage. However this would have little effect on the model's results in the main areas of interest.

It is concluded that the damper-modelling algorithms in FLUE SIMULATOR provide a good simulation of the actual behaviour of dampered flues and that the model can be used with a fair degree of confidence to study the influence of dampers on combustion venting performance. However, further comparisons with field data would be worthwhile - especially data from tests on exterior chimneys in cold weather, since the comparison reported here was for an interior chimney tested when the outdoor temperature was moderate.

PARAMETRIC STUDY

A parametric study was undertaken to investigate the effect flue dampers have on the ability of the venting system of a naturally aspirating furnace to resist standby backdraft and start-up spillage.

A plan of was drawn up for an investigation using the FLUE SIMULATOR program. The objective was to investigate the effect a flue damper has on the House Depressurization Limit of a flue/-furnace/house system and how the damper interacts with other elements of the system.

The detailed methods used and results found in the study are described in Appendix B.

The results of the parametric study begin to give insights as to the effect of dampers on chimneys. The following appear to be key factors in determining the impact of dampers:

- location of chimney (inside or outside the envelope)
- chimney liner time constant
- duration of the off-cycle (standby)
- outdoor temperature
- flow area around the closed damper

The effect of dampers on interior chimneys is small since these need not depend on heat from the furnace or pilot light to stay warm. Similarly, as the outdoor temperature increases, the effect of dampers on exterior chimneys is reduced.

The effect of dampers on heavy chimneys appears to be small since the heavy liner "carries" the chimney through most standby periods. This should not be construed as an endorsement of heavy

exterior chimneys since these may be undesirable for other reasons (e.g. such chimneys have high condensation potential). Stated simply, dampers appear not to worsen the venting performance of masonry chimneys.

The combination of a light exterior chimney, a damper, and prolonged standby periods in cold weather (such as encountered when a thermostat setback is used) appears to be a problematic one in that the net theoretical draft at standby becomes negative in such cases. This results in backdrafting at standby.

In cases where standby backdrafting is induced by house depressurization, the damper has the effect of slowing down the reversing flow in the chimney. This slowing action allows the air in the flue to recover some heat from the liner. Thus, depending on the mass of the liner, the exterior temperature and the length of standby period likely to be encountered, a dampered chimney can require a higher level of depressurization to cause irreversible spillage at start-up than an equivalent non-dampered chimney. This was the case for the masonry chimneys for the conditions studied.

For dampers installed on light chimneys, the effect of decreasing the damper's free venting area in the closed position is to reduce the period over which the chimney can maintain a positive draft at standby. A smaller free venting area in the closed position was also shown to decrease the level of depressurization necessary to cause irreversible spillage at start-up. Neither effect was found to be very pronounced unless the free venting area in the closed position was less than 10% of the vent connector area.

CONCLUSIONS

In summary, this study has attempted to highlight some of the effects that dampers may have on chimney performance as well as the variables that can influence those effects.

It has been shown that the presence of a damper increases the draft in a light exterior chimney immediately after furnace shutdown as compared to a similar non-dampered chimney. However, after prolonged periods of standby, the dampered chimney, deprived of its main source of heat, eventually loses its advantage over the non-dampered chimney and becomes more susceptible to standby backdrafting.

For light chimneys operating under low draft conditions (e.g. house depressurized by exhaust fans), the presence of a damper reduces the level of depressurization necessary to cause irreversible backdrafting; i.e. makes the chimney more susceptible to backdrafting. This seems to be especially true of thermal dampers. However this effect is not very pronounced unless the damper's free venting area in the closed position is approximately 10% of the vent connector area or less.

Another apparent difference between thermal and electrical dampers is that, in a strong depressurization, where the thermal damper cannot open (because the flue gas cannot reach it), undiluted furnace stack gases will spill into the room. An electrically-activated damper is automatically forced open, allowing a flow of outside air down through the chimney to mix with the furnace stack gases.

The effects of the presence of a damper decrease as the mass of the liner increases. Dampered heavy chimneys can actually perform better than non-dampered heavy chimneys under low draft conditions.

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APPENDIX A

PROCEDURE FOR INSTALLING THERMALLY ACTUATED AUTOMATIC VENT DAMPERS SPECIFIED IN CSA STANDARD CAN1-6.14-M86

EXHIBIT B

PROCEDURE FOR INSTALLING THERMALLY ACTUATED AUTOMATIC VENT DAMPER DEVICES ON EXISTING APPLIANCES

This procedure is intended as a guide to aid in safely installing a thermally actuated automatic vent damper device on an existing appliance.

This procedure is based on the assumption that the history of the specific appliance has been one of safe and satisfactory operation.

This procedure is predicated on central furnace, boiler and water heater installations, and it should be recognized that generalized procedures cannot anticipate all situations. Accordingly, in some cases deviation from this procedure may be necessary to determine safe operation of the equipment.

The following steps are to be followed in making the modifications:

1. Perform a safety inspection of the existing appliance installation. See Exhibit A for a recommended procedure for such a safety inspection.

2. Shut off all gas and electricity to the appliance. To shut off gas use the shutoff valve in the supply line to the appliance.

3. Install the thermally actuated automatic vent damper device in strict accordance with the manufacturer's installation instructions. Make certain the device is not located in that portion of the venting system which serves any appliance other than the one for which the damper is installed.

4. Make certain wiring connections are tight and wires are positioned and secured so they will not be able to contact high temperature locations.

5. When an additional automatic valve has been incorporated or an existing gas control replaced, conduct a gas leakage test of the appliance piping and control system downstream of the shutoff valve in the supply line to the appliance.

6. Visually inspect the modified venting system for proper horizontal pitch.

7. Check the installation to determine there is no physical obstruction or deformation which could impair damper operation.

8. Determine the amperage draw of the gas control circuit and damper device.

   (a) Check appliance transformer for adequate capacity.

   (b) Check heat anticipator in comfort thermostat to determine it is properly adjusted.

9. Sequence the appliance through at least three normal operating cycles.

10. Insofar as is practical, close all building doors and windows and all doors between the space in which the appliance is located and other spaces of the building except in a room where an exhaust fan is located. Turn on clothes dryers, stove top barbecues and central vacuum cleaners. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers. Do not install a damper device unless sufficient combustion air is available.

11. Place appliance in operation. Follow the lighting instructions. Prior to placing in operation, be sure the appliance has been off at least 15 minutes. Adjust thermostat so appliance will operate continuously. If the appliance is equipped with mult-rate or modulating controls, conduct the tests specified under Steps 12 and 13 at both the appliance's maximum and minimum input rates.

12. Test for spillage at the draft hood relief opening after two minutes of main burner operation. Use a draft gauge, flame of a match or candle, or smoke from a cigarette, cigar or pipe.

If spillage occurs after two minutes of operation, do not install the damper.

13. Visually determine that main burner gas is burning properly: i.e., no floating, lifting or flashback. Adjust the primary air shutter(s) as required.

14. Determine that the pilot(s) is burning properly and that main burner ignition is satisfactory by interrupting and re-establishing the electrical supply to the appliance in any convenient manner. Test the pilot safety device to determine it is operating properly by extinguishing the pilot burner(s) when the main burner(s) is off and determining, after 3 minutes, that the main burner gas does not flow upon a call for heat.

15. Applicable only to furnaces - Check both the limit control and the fan control for proper operation. Limit control operation can be checked by blocking the circulating air inlet or temporarily disconnecting the electrical supply to the blower motor and determining that the limit control acts to shut off the main burner gas.

16. Applicable only to boilers -

    (a) Determine that the water pumps are in operating condition.

    (b) Test low water cutoffs, automatic feed controls, pressure and temperature limit controls and relief valves in accordance with the manufacturer's recommendations to determine they are in operating condition.

17. Label the damper device (see 1.9.3) with information as to:

    (a) Name of qualified agency responsible for damper installations.

    (b) Date of installation.

APPENDIX B

PARAMETRIC STUDY

THE INFLUENCE OF FLUE DAMPERS ON THE VENTING PERFORMANCE OF FLUES

PARAMETERS AND CONDITIONS INVESTIGATED

The effects of electrically- and thermally-activated dampers on three types of chimneys were investigated. These chimney types were:

- B-vent
- A-vent
- Masonry

A reference house and ambient conditions were chosen to highlight the effects being investigated. Two key conditions that were thought to play important roles in the problem are the location of the flue (i.e. interior vs. exterior chimney) and the outdoor temperature. Because it is the quantity of residual energy in the flue at standby that is the focus of this study, an exterior chimney operating in cold weather would highlight the decay in this residual energy. Thus a cold day (-10°C) and an exterior chimney were chosen for the reference case. Appendix C shows the envelope specifications and furnace characteristics of the reference house.

The following elements of the problem were investigated.

- type of damper (electric, thermal)
- chimney mass (time constant)
- type of furnace (oil, gas)
- location of chimney (interior, exterior)
- furnace heat exchanger mass (time constant)
- duration of off-cycle
- flow area of the damper in the closed position

Parameters that were fixed in the study were:

- house airtightness
- furnace firing rate

- chimney and flue pipe vertical dimensions
- ambient temperatures

Variables not investigated in conjunction with dampers were the effects of:

- a hot water heater connected to the same flue
- a draft inducer
- thermostat setback

Choice of Flue Diameters

The cross-sectional area of each chimney was based on the standard size for the chosen size of furnace. The A-vent and B-vent were assigned the same area cross-sectional area of 0.0127 m^2 (6" round chimney). The masonry chimney was assigned a cross-sectional area of 0.024 m^2 (6.5" square). A detailed description of each chimney investigated in the study is given in Appendix D.

Although the above chimney specifications result in at least two chimney diameters being investigated, other factors were also modified at the same time (e.g. liner mass), so that the effect of chimney size was not investigated on its own. The effect of chimney diameter is considered to be small in this problem since the flow area around the closed damper controls the flue flow rate at standby, regardless of the flue diameter.

Establishing Initial Conditions

It has been shown that the performance of any given installation at any given time is strongly dependent on the

previous operating history of that installation. Thus, depending on whether a damper was or was not present on a particular chimney in previous cycles, the initial conditions of two otherwise identical chimneys may be different. This may be the reality but it adds an additional dimension to the analysis making it difficult in some cases to determine if the performance of a chimney is a result of the damper or the initial conditions. In order to net out the extraneous effects of differing residual energies in the chimney that may be a result of the presence or absence of the damper in previous cycles, it was decided to start the simulations of all chimneys at the same initial conditions. These initial conditions are described in the input sheets in Appendix C. Since it is the relative performance of the chimney with and without the damper that is of interest, the actual choice of initial conditions is not important (so long as they are the same for the "with" and "without" cases). The values shown in the input sheets are typical of initial conditions of the furnace/flue system in steady state standby conditions.

Using these initial conditions, all simulations began with the same preparatory cycle consisting of 5 minutes of heat-up (to provide the initial energy input to the system). The performance comparisons reported below focussed on the cool-down portion of the cycle following this heat-up and the subsequent start-up.

THE INFLUENCE OF FLUE DAMPERS ON THE VENTING PERFORMANCE OF FLUES

THE EFFECT OF DAMPERS ON STANDBY NET THEORETICAL DRAFT*

Each of the three chimneys was allowed to cool-down for 45 minutes with and without the damper activated. The results are shown in Figures B1, B2 and B3. The presence of the damper was shown to affect the B-vent and the A-vent in a similar way. With the dampers, both chimneys operated warmer just after furnace shut off. This resulted in net theoretical draft values that were up to 3 Pa higher than the cases without the dampers. This was an unexpected result although, in retrospect, it is easily explained - the damper prevents cooling of the chimney liner surface normally caused by the flow of cooler room air flowing through the dilution port and up the chimney.

However, as the cool-down proceeds, the expected result occurs - the dampered chimney, deprived of its main source of standby heat, loses its stored heat to the exterior and begins to cool more rapidly than the non-dampered chimney. The net theoretical draft of the dampered chimney eventually drops below that of the non-dampered chimney. The time it takes for this cross-over to occur is shown in the following table:

CHIMNEY TYPE	Duration after shutdown over which the dampered chimney shows an advantage over the non-dampered
B-Vent	650 seconds (approx.)
A-Vent	550 seconds (approx.)

* Theoretical draft generated by chimney minus the buoyancy of a parallel column of indoor house air measured from the dilution port of the furnace to the vertical centre of leakage of the building envelope.

During the period before cross-over, the B-vent showed a slightly higher net theoretical draft than did the A-vent. This reflects the lower chimney time constant for the B-vent (commensurate with its lighter mass) relative to the A-vent. As a result, the energy from the liner of the B-vent is transferred to the flue gas faster than the A-vent. However, after 10 minutes, the net theoretical draft for the B-vent and the A-vent are identical. At the end of 15 minutes, the dampered B-vent had a lower net theoretical draft (1.5 Pa) than did the A-vent (the A-vent has more residual energy in its liner at this time than the B-vent).

For both the B-vent and A-vent with a damper, the net theoretical draft continues to drop after 15 minutes of cool-down. In fact, given enough time (approximately 25 minutes) the net theoretical draft for the B-vent drops below zero and the chimney begins to backdraft. After 30 minutes, the net theoretical draft has dropped to -2 Pa and is still dropping. The furnace, if started under this condition, may be unable to reverse the backdrafting. A similar pattern was observed for the dampered A-vent although it took over 40 minutes before the net theoretical draft in the A-vent dropped below zero. On the other hand, the chimney with no damper has settled at a net theoretical draft of about 4.5 Pa, providing a healthy, positive draft in the chimney (albeit at some energy cost).

The masonry chimney reacted differently to the damper than did the A-vent or the B-vent. The net theoretical draft of the masonry chimney with a damper dropped off immediately and dramatically after furnace shut-off compared to the same chimney without the damper. The greatest difference in net theoretical draft was 4.7 Pa, occurring shortly after shut down. In fact, the net theoretical draft of the dampered masonry chimney was always below the net theoretical draft of the non-dampered masonry chimney. However, despite a rapid drop in the net

theoretical draft during the first 10 minutes with damper installed, both the dampered and non-dampered masonry chimneys settle out at about the same net theoretical draft after 15 minutes or so (approximately 4.3 Pa for the chimney with damper and 5.2 Pa for the chimney with no damper). Thus there was no apparent cross-over point for the standby periods tested.

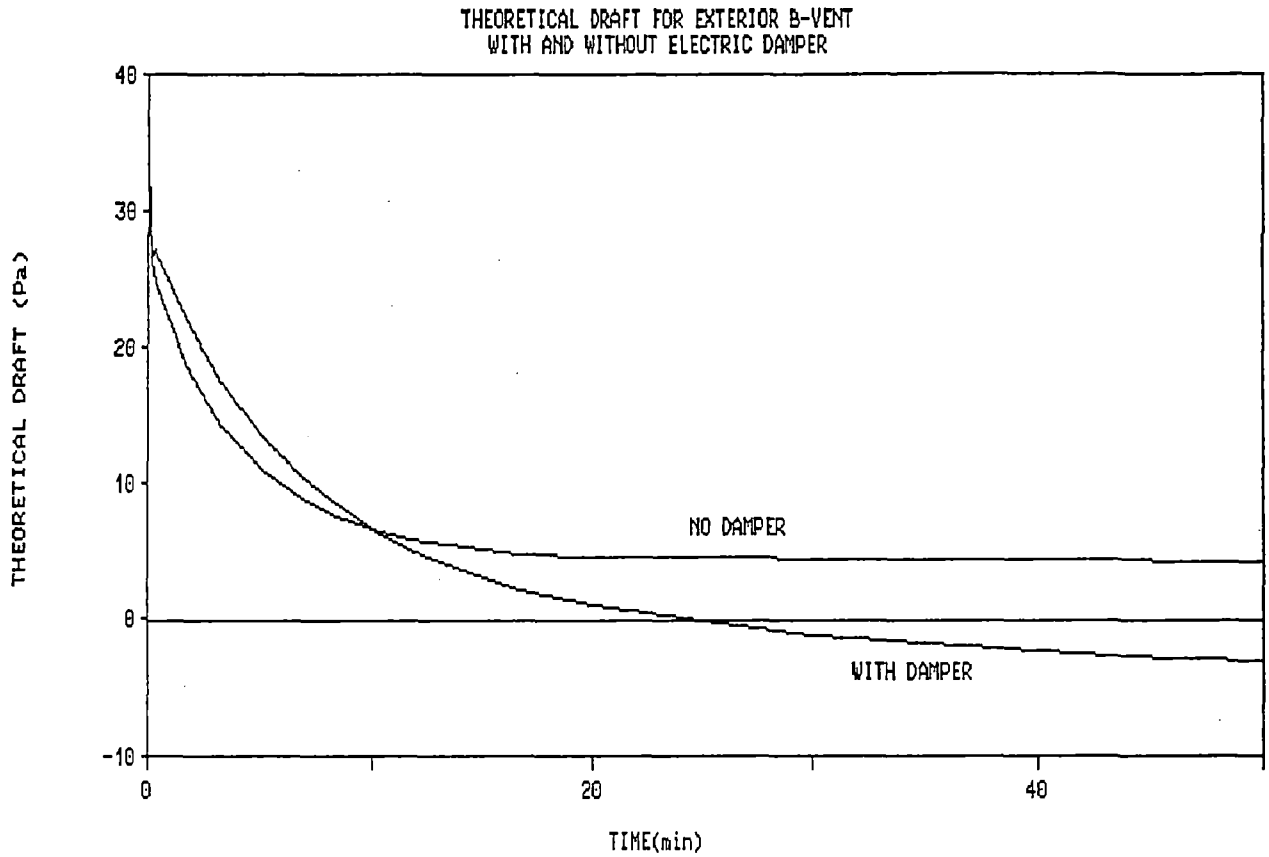


FIGURE B1: Net theoretical draft for exterior B-Vent with and without an electric damper for a gas furnace at standby. (T_{out}: -10°C).

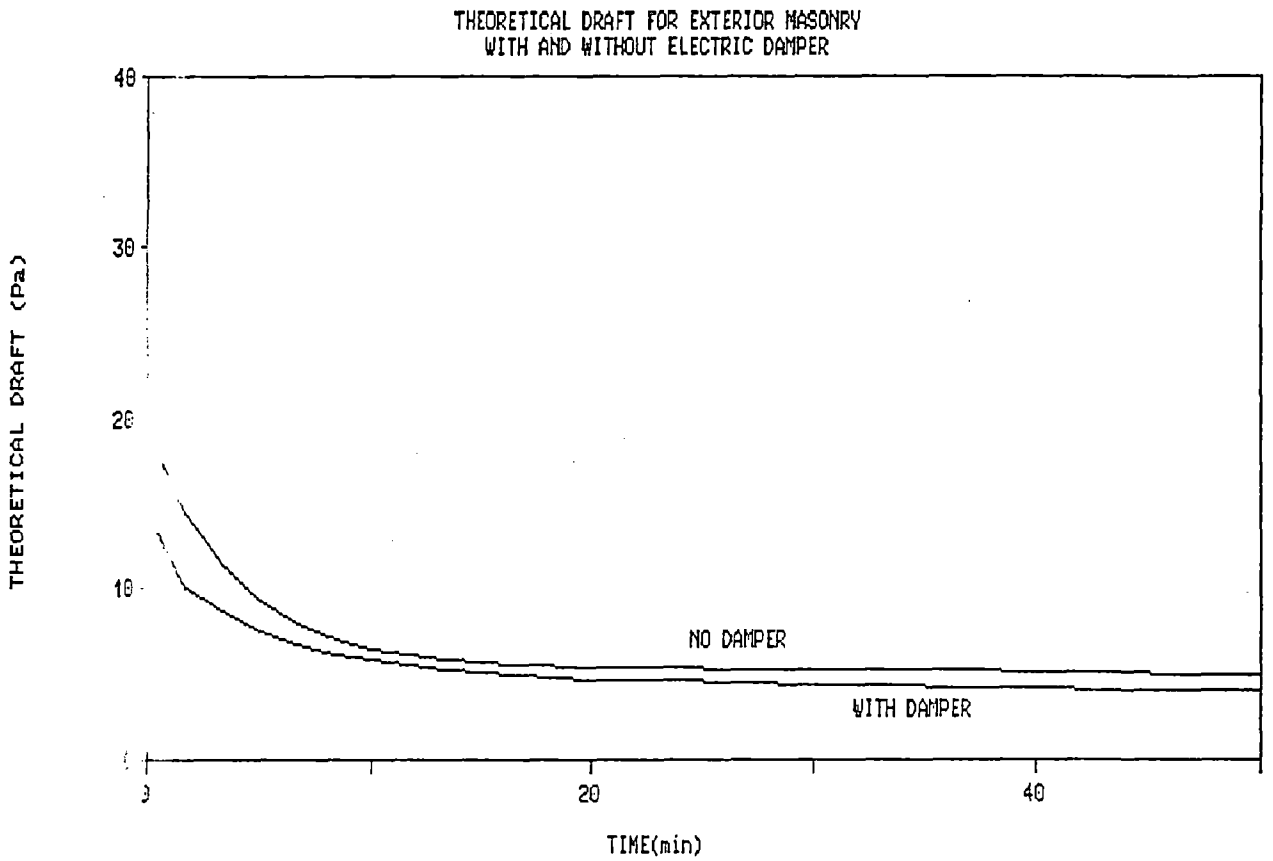


FIGURE B2: Net theoretical draft for exterior masonry chimney with and without an electric damper for a gas furnace at standby. (T_{out}: -10°C).

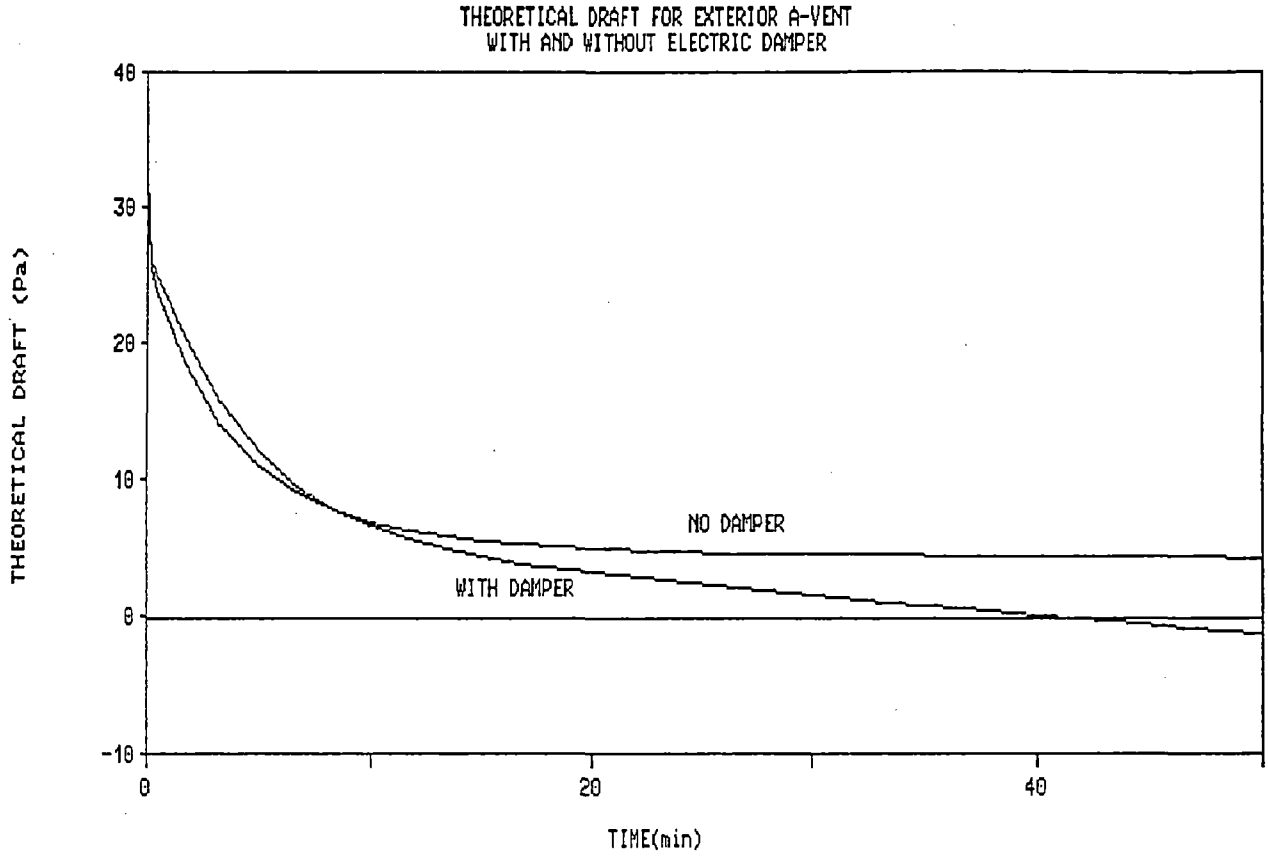


FIGURE B3: Net theoretical draft for exterior A-Vent with and without an electric damper for a gas furnace at standby. (T_{out}: -10°C).

EFFECT OF DAMPERS ON START-UP SPILLAGE DURATION

The standby simulations described above have shown that, for light chimneys under the conditions simulated, the cool-down behaviour of the chimney can be described by three distinct regimes. These are:

1) A period during which the net theoretical draft of the dampered chimney is higher than that of the non-dampered chimney.

2) A period during which the net theoretical draft of the dampered chimney is still positive but below that of the non-dampered chimney.

3) A period during which the net theoretical draft of the dampered chimney is less than zero and the chimney backdrafts.

In each of these regimes there is a distinct difference in the net theoretical draft between the dampered and non-dampered chimneys reflecting differences in the amount of residual energy remaining in the liner and the amount of room air tempering the loss of that residual energy to the outside. In selecting the initial conditions for spillage tests, care was taken to minimize differences in residual energy since this would confuse the conclusions that might be drawn on the impact of dampers alone. As a result, for the spillage simulations it was decided to simulate furnace start-up 15 minutes into the cool-down cycle described previously. At this point the differences in net theoretical draft between the dampered and non-dampered chimneys were sufficiently small that they would have little effect on the final results. (Since the comparisons involved chimney systems identical except for the presence or absence of a damper, nearly

equal net theoretical drafts indicate nearly equal residual energy levels.)

Following the cool-down period described above, each configuration was subjected to depressurization and, after one additional minute of standby operation, the furnace was turned on. This was repeated at succeedingly higher levels of depressurization until irreversible backdrafting (i.e. start-up spillage continuing indefinitely) occurred. Plots of flow versus time from these simulations are shown in Appendix E.

The results of this exercise show that the damper increases spillage duration for all chimneys, although this increase was only marginal for house depressurization below the level necessary to cause irreversible backdrafting (e.g. increases in the order of 2 to 3 seconds were observed up to 75% of the level necessary to cause irreversible backdrafting).

Table B1 compares the level of house depressurization necessary to cause irreversible backdrafting with and without dampers for an exterior masonry and an exterior B-vent chimney. The results show that, for the conditions tested, the presence of the damper lowered this level for the exterior B-vent by about 1.3 Pa. Interestingly enough, the presence of the damper increased this level for the exterior masonry chimney by about 0.6 Pa. Thus, for these aforementioned conditions, the presence of the damper has a negative effect on the B-vent, creating conditions that will cause irreversible backdrafting at lower levels of depressurization compared to an identical non-dampered chimney. On the other hand the damper has a beneficial effect on the masonry chimney, marginally increasing its tolerance of depressurization.

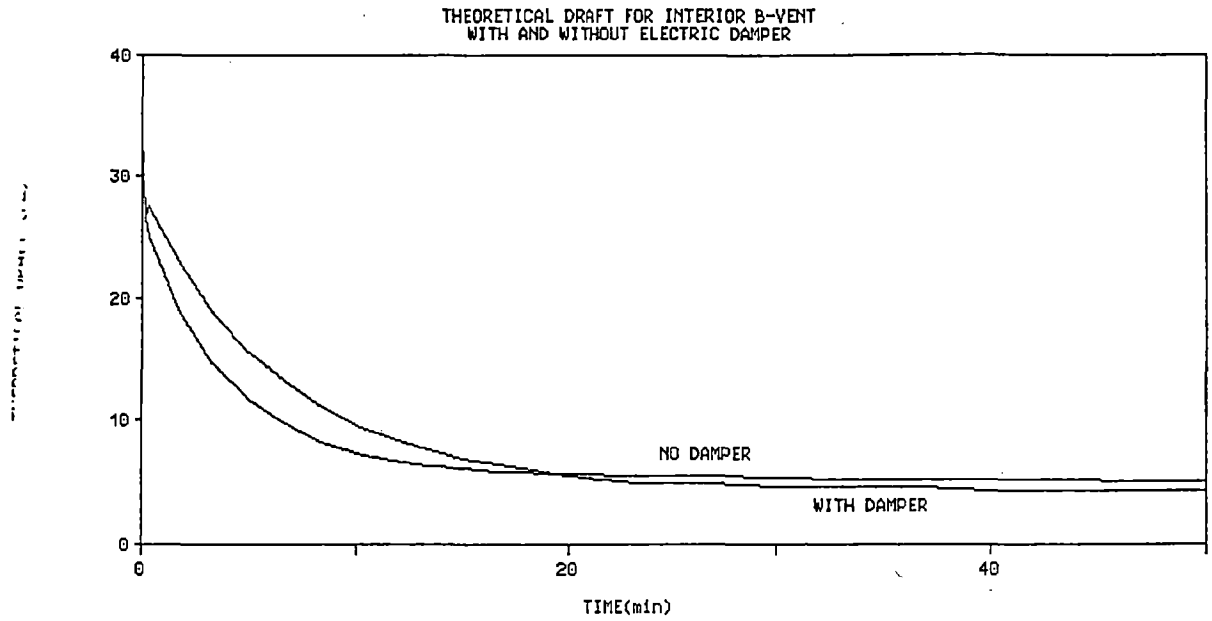
Table B1: House Depressurization Level Necessary to Cause Irreversible Backdrafting.

Type of Exterior Chimney	without damper	with damper
B-Vent	4.7 Pa	3.4 Pa
Masonry	6.2 Pa	6.8 Pa

It must be mentioned at this point that the details of the above results are illustrative only and are applicable only for the simulation protocol described above. For example, if outdoor temperature, initial conditions or duration of depressurization had been different, the results in the table above would also have been different. However, the conclusions regarding the relative performance of dampered and non-dampered chimneys may be more generally applicable.

EFFECT OF CHIMNEY LOCATION

The effect of chimney location was investigated by comparing net theoretical draft decay curves for two interior B-vents, one with a damper and one without. The results are shown in the top graph of Figure B4. The damper appears to have little or no effect on the standby buoyancy of the interior chimney. The bottom graph is the decay curve for the exterior B-vent (repeat from Figure B1), and is provided to facilitate comparison of interior and exterior chimneys.



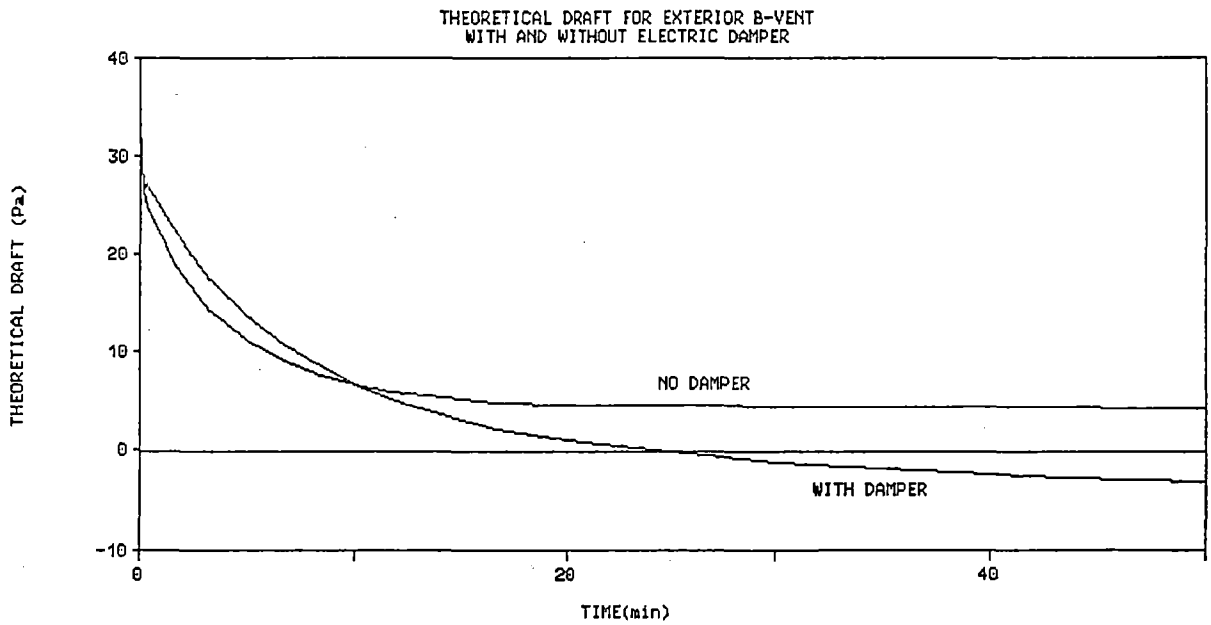


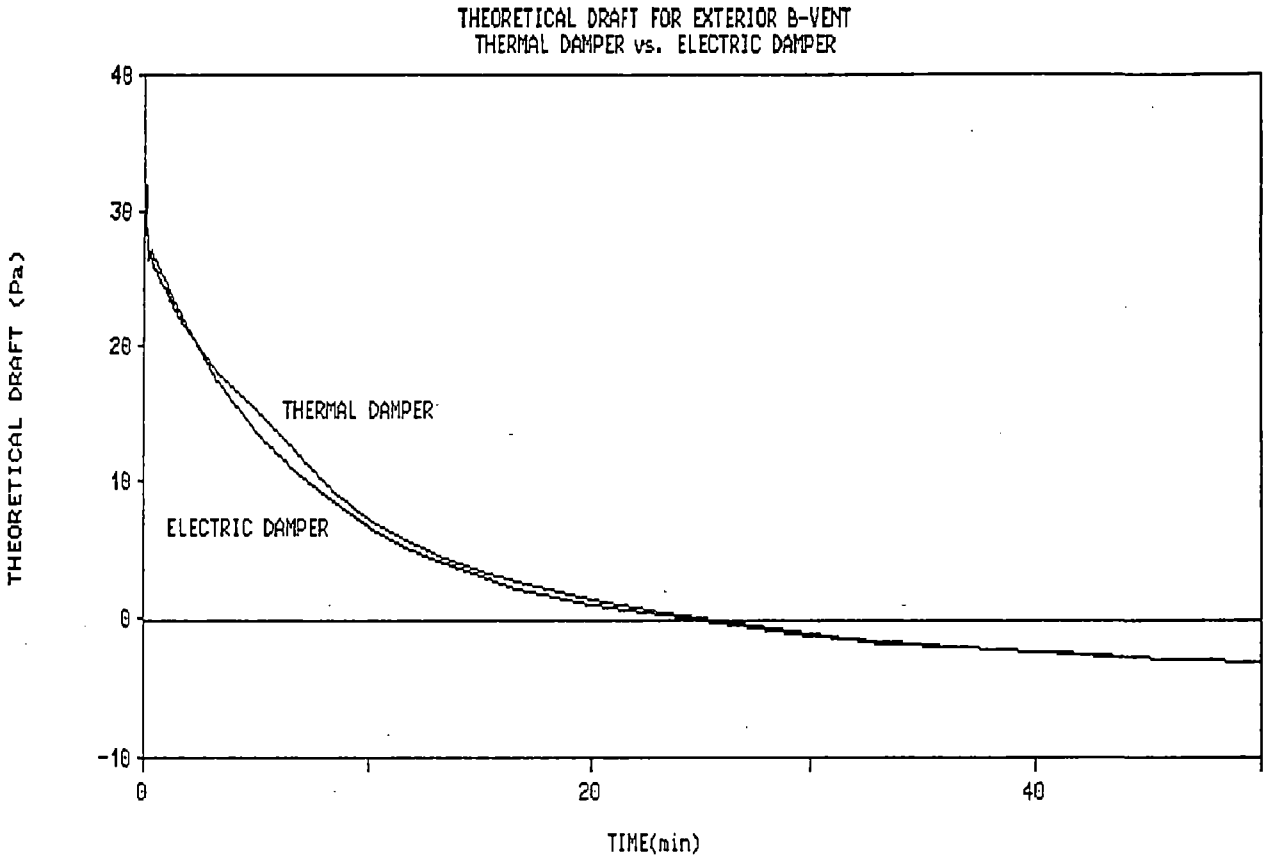
FIGURE B4: Comparison of the effect of electric dampers on the net theoretical draft of an interior and exterior B-Vent. (T_{out}: -10°C).

EFFECT OF DAMPER TYPE

Since the following comparisons are designed to be illustrative of the effects of damper behaviour only, the venting area in the closed position was fixed at 0.0003 m^2 for both the electric and thermal dampers even though thermal dampers are limited to a minimum free venting area in the closed position of 10% of the vent connector area; in this case 0.00127 m^2. Effects of free venting area in the closed position are discussed in a separate section below.

Figure B5 shows comparative standby driving pressure decay curves for identical B-vent chimneys, one with an electrically-activated damper and one with a thermally activated damper. Except for small differences in net theoretical draft just after furnace shutdown, the thermally-activated damper appears to affect the standby performance of the flue much like the electrically-activated damper.

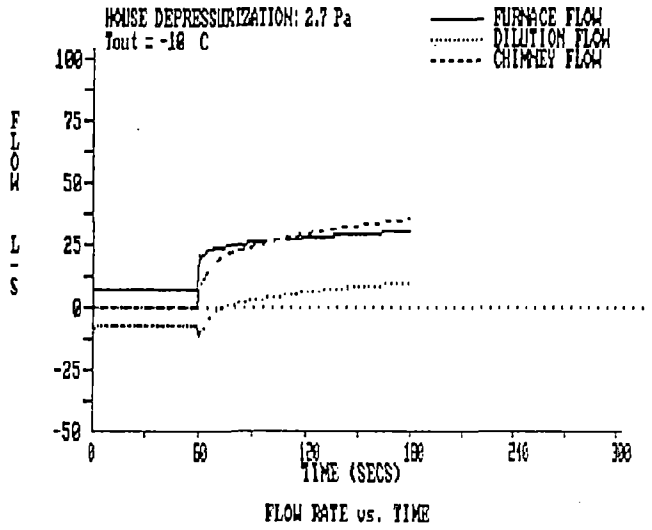
Figure B6 shows comparative graphs of flow vs. time for an exterior B-vent installed with an electrically-activated damper and an exterior B-vent installed with a thermal damper under low start-up draft conditions. In a low start-up draft situation, the thermally-activated damper appears to cause spillage for a longer duration than the electrically-activated damper. In these simulations, each damper was subjected to 60 seconds of depressurization at 2.7 Pa then the furnace was turned on. With a thermal damper installed, the duration of spillage was 90 seconds, whereas the same chimney with an electrically-activated damper spilled for only 9 seconds. This difference can be explained by the fact that the electrically-operated damper is modelled to open instantaneously whereas the thermally-operated damper is modelled to open gradually in response to flue gas temperature.



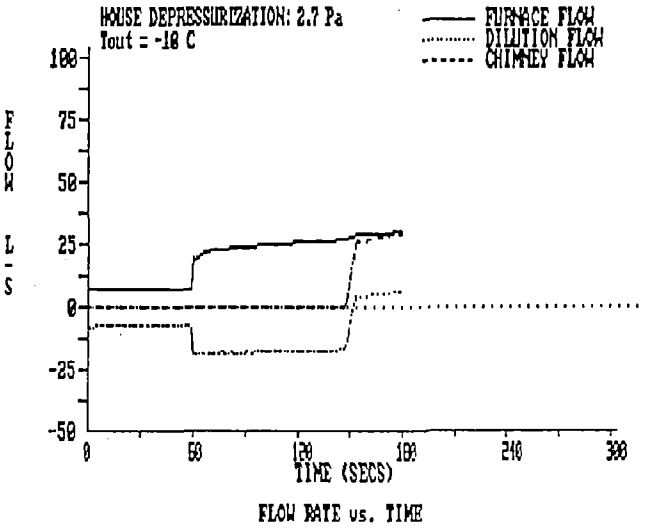
Note: Free venting area in the closed position =0.0003m^2 for both thermal and electric damper

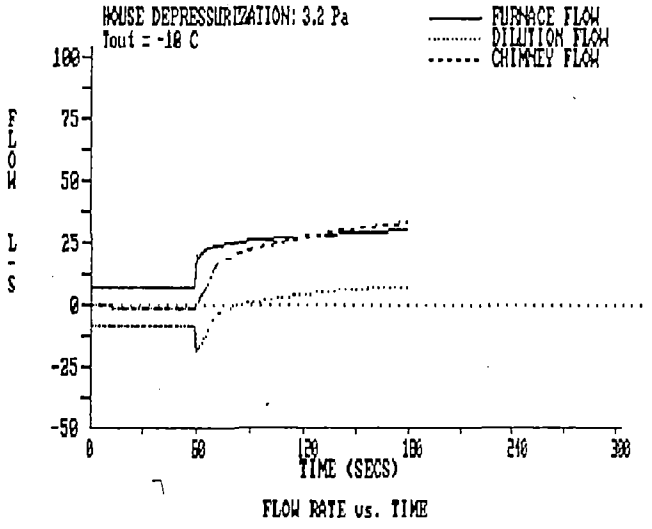
FIGURE B5: Comparison of the effect of thermal and electric dampers on the net theoretical draft of an exterior B-Vent. (T_{out}: -10°C).

Electric damper



Thermal damper





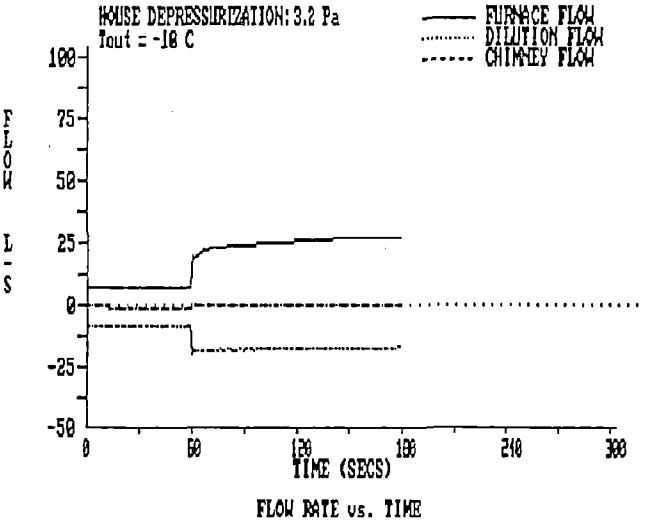


FIGURE B6: Comparison of spillage duration for thermal and electric dampers installed on an exterior B-Vent. (T_{out}: -10°C).

Note that the initial conditions used in these and all other simulations carried out in the parametric study were representative of a standby period long enough that the benefit of a damper in keeping a chimney warmer immediately following furnace shutdown (as reported under THE EFFECTS OF DAMPERS ON STANDBY NET THEORETICAL DRAFT) is lost.

The level of house depressurization necessary to cause irreversible backdrafting for the thermal damper was found to be about 2.8 Pa. The maximum level with the electrically-activated damper was 3.4 Pa. Thus, the simulations suggest that in low draft situations, the thermal damper does not perform as well as an equivalent electric damper. Again, this is attributable to the fact that the thermal damper is modelled to open gradually, thus restricting the transfer of furnace heat to the chimney.

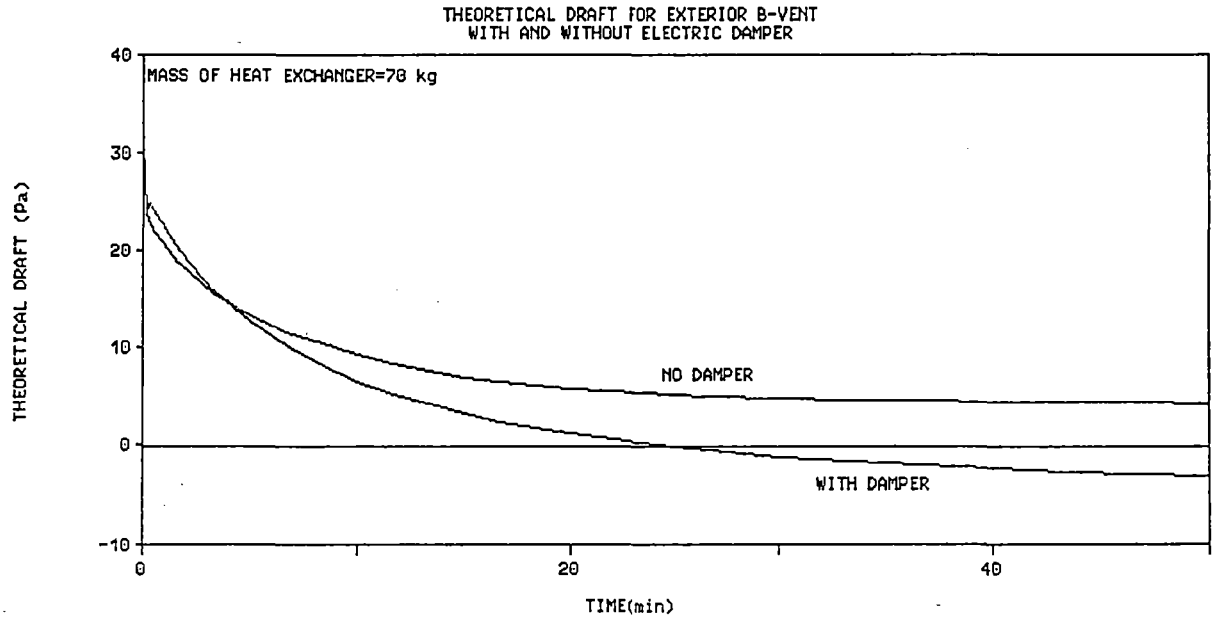
EFFECT OF DAMPERS ON THE VENTING OF OIL FURNACES

Heat-up/cool-down and start-up simulations of exterior masonry chimneys serving oil furnaces (results not shown) indicated that the presence of a damper in the venting system of an oil furnace appears to have little or no affect on venting performance at start-up. The level of depressurization necessary to cause irreversible backdrafting (under the same furnace-house conditions as were created for the gas furnace) was the same with and without the damper. This may be due in part to the fact that the oil furnaces rely more on blower action to initiate draft than on the net theoretical draft of the chimney at standby.

EFFECT OF HEAT EXCHANGER MASS

Figure B7 shows standby net theoretical draft decay curves for dampered and non-dampered chimneys serving furnaces with two different heat exchanger masses. The top graph compares the decay curves for dampered and non-dampered B-vents serving furnaces with heat exchanger mass doubled from that used in the reference configuration, thereby doubling the time constant of the furnace. The bottom graph is the decay curve for the exterior B-vent with a furnace heat exchanger mass as defined in the reference configuration (repeat from Figure B1), and is provided to facilitate comparison of the effect of varying furnace mass on exterior chimneys.

The increased furnace time constant had the effect of increasing the standby buoyancies for the non-dampered flues, but had no effect on the dampered flues, as may be expected. The explanation is that the dampered flues must rely mainly on their own internally stored heat to generate draft but the non-dampered flues have greater access to the residual heat in the furnace heat exchanger.



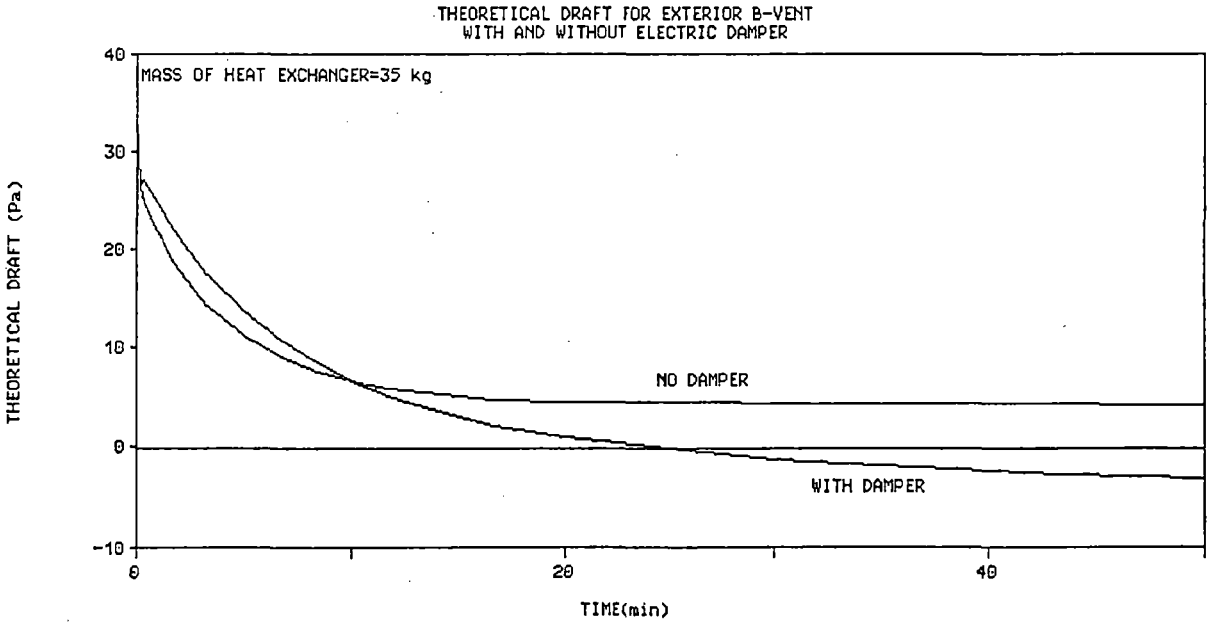


FIGURE B7: Comparison of the effect of electric dampers on the net theoretical draft of an exterior B-vent with different furnace mass. (T_{out}: -10°C).

EFFECT OF OUTDOOR TEMPERATURE

The effect of outdoor temperature was not examined explicitly. However, the indoor chimney simulations can be interpreted as an approximation of the condition where the outdoor temperature is equal to the indoor temperature. Based on these results we can say that, as the outdoor temperature increases, the relative difference in draft between dampered and non-dampered chimneys will decrease. Conversely, as the outdoor temperature decreases, the period over which a dampered chimney can maintain positive draft will also decrease. The effect will be more pronounced on lighter chimneys (B-vent, A-vent).

EFFECT OF FLOW AREA

Two simulations of the thermal damper installed on an exterior B-vent were run. In one simulation, the free venting area in the closed position was set at 0.0003 m^2 (this is the minimum required free venting area in the closed position for electric dampers). In the other simulation that area was increased to 0.00127 m^2 (the minimum area specified by codes for thermal dampers).

As before, the results were analyzed in terms of the effect on the net theoretical draft at standby after a 5 minute heat-up and the effect on start-up spillage duration.

Standby Draft

The standby net theoretical draft decay curves for an exterior B-vent with different damper areas (including the

non-dampered case) are shown in Figure B8. The following is a discussion of those results.

During the first 10 minutes of the cool-down period there was virtually no difference in the net theoretical draft for the chimney with the larger area damper compared to the smaller area damper. Both profiles had a higher draft than a non-dampered chimney.

After 10 minutes, the net theoretical draft for the non-dampered chimney was beginning to reach a steady state level of 4.5 Pa. The net theoretical draft for both dampered chimneys continued to drop. Thus, after approximately 15 minutes, the non-dampered chimney was showing a definite advantage over the dampered chimneys. At approximately the same time, the draft of the chimney with the damper with the smaller free venting area in the closed position began to fall below that of the chimney with the damper with the larger area.

Eventually, the net theoretical draft for both dampered chimneys fell below zero and the chimneys began to back-draft. The damper with the larger free venting area in the closed position was able to maintain a positive draft for 5 minutes longer than the damper with the smaller area. This is explained by the fact that a larger free venting area in the closed position allows more room air up the chimney which matches the heat loss from the liner at a higher equilibrium temperature. The extreme, of course, is the non-dampered chimney which, for the conditions simulated, was able to maintain a positive draft indefinitely.

In the case of the damper with the larger area, once the net theoretical draft fell below zero, it dropped very quickly, eventually falling below the draft of the chimney with the

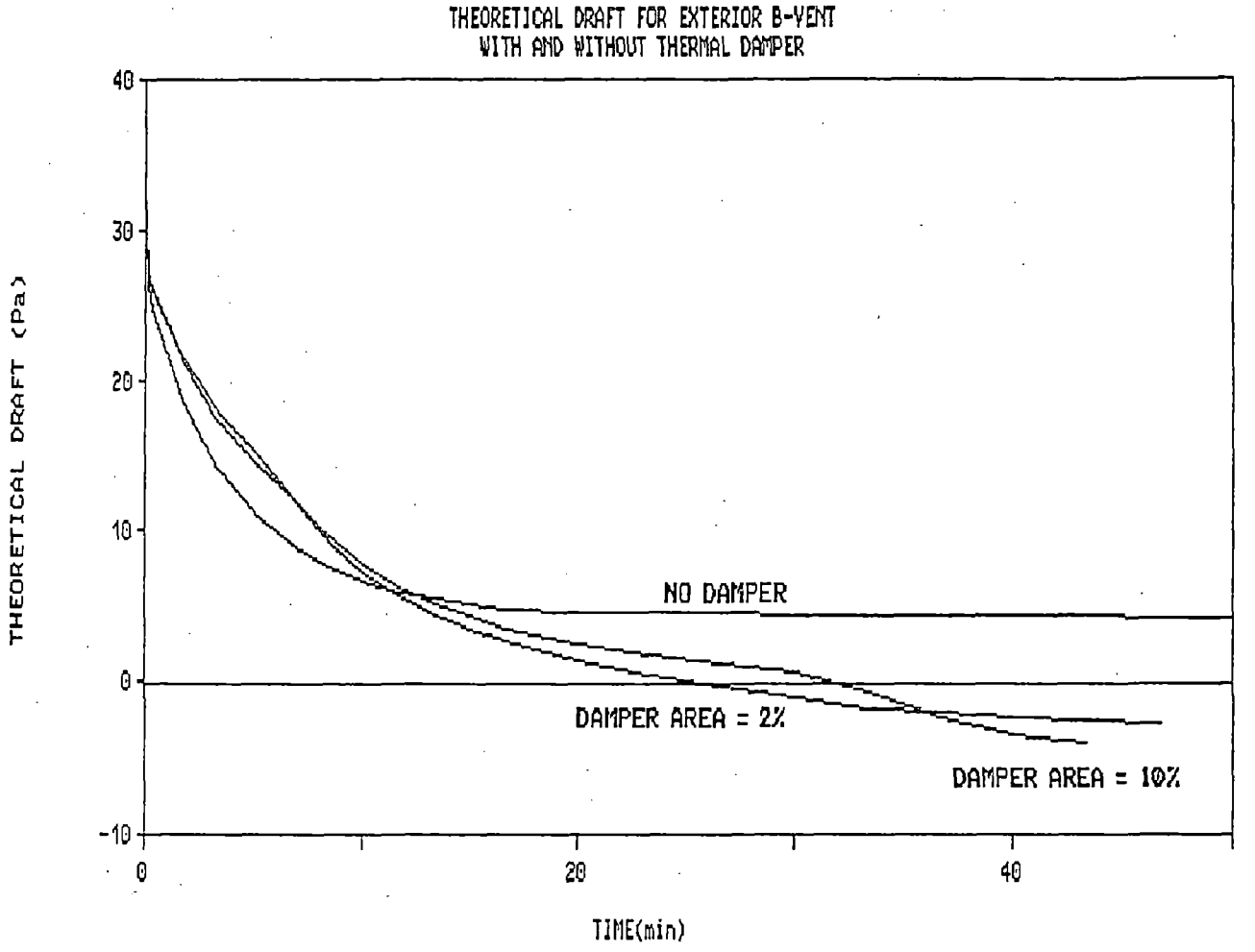


FIGURE B8: Comparison of the effect of different free venting areas in the closed position on the net theoretical draft of an exterior B-vent. (T_{out}: -10°c).

smaller area (the slope of the net theoretical draft for the damper with the smaller area remained essentially constant as it crossed the threshold from positive draft to negative draft). This is explained by the fact that the damper with the smaller area restricts downward flow of outdoor air in the chimney (compared to the chimney with the larger area) allowing the outdoor air to pick up residual energy from the liner. Eventually, given a long enough standby condition, the liner would be cooled down sufficiently that the effects of free venting area in the closed position would no longer be a factor in the draft of the chimney (i.e. the two curves will eventually merge).

Start-up Spillage Duration

The test protocol to investigate start-up spillage duration was the same as discussed earlier - following 15 minutes of cool-down, each configuration was subjected to depressurization and after one additional minute of standby operation, the furnace was turned on. This was repeated at succeedingly higher levels of depressurization until irreversible backdrafting occurred. The results of these tests are shown in the Table 2 below.

Table B2: House Depressurization Level Necessary to Cause Irreversible Backdrafting

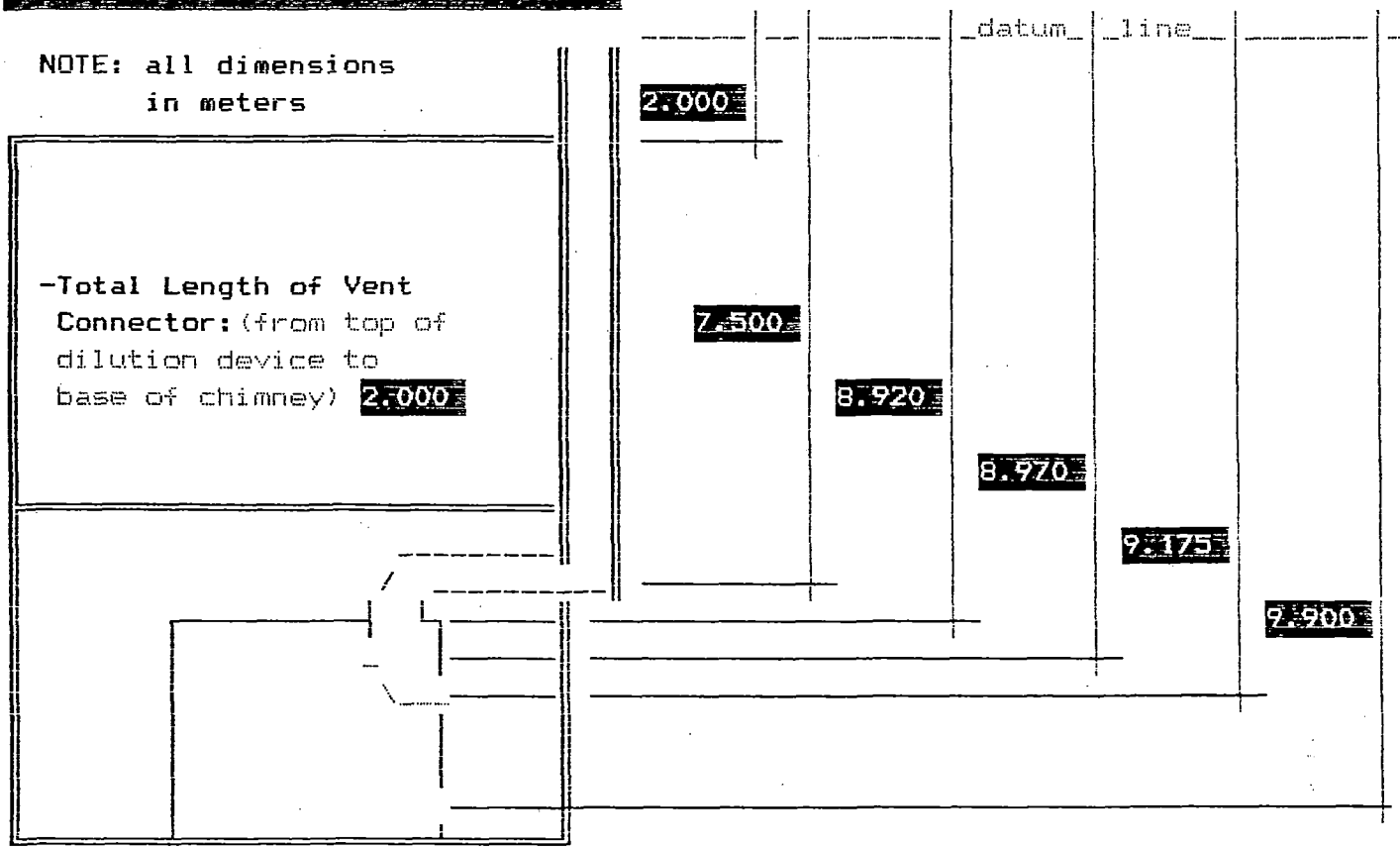
Free Venting Area in the Closed Position		Depressurization(Pa)	
m^2	% of vent connector area	Thermal	Electric
0.0127	100	4.9	4.9
0.00127	10	4.7	4.2
0.0003	2	2.8	3.5

In summary, the effect of increasing the thermal damper's free venting area in the closed position from 2% to 10% of the vent connector area was to increase the level of house depressurization necessary to cause irreversible backdrafting from 2.8 Pa to 4.7 Pa. Increasing the area from 10% to 100% provides only an additional 0.2 Pa improvement. The relationship is not linear. A similar result was found for the electric damper (results also shown in Table 2). Thus, it appears that the critical level of depressurization is increased if the free venting area of the damper is increased. This is because increasing the area allows more heat from the pilot light and room to escape to the chimney, thus keeping the flue warmer and helping to maintain a positive draft. This, of course, reduces the energy conservation benefits of the damper. The non-linearity of the results indicates that, for a given damper type, there may be an optimum free venting area which represents the best compromise between energy conservation and combustion venting objectives. Determining that optimum area and investigating the mechanisms that differentiate electrically-activated from thermally-activated dampers would require additional simulations with various initial conditions (different combinations of cool-down and durations of house depressurization before furnace start-up), which is beyond the scope of this project.

APPENDIX C

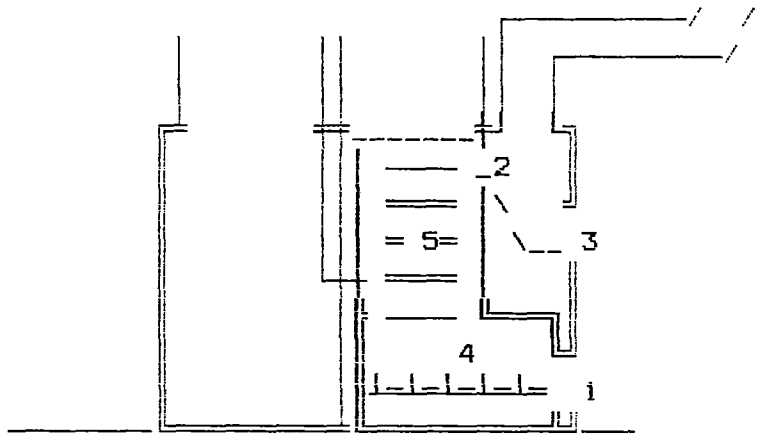
INITIAL CONDITIONS AND ENVELOPE AND FURNACE DETAILS OF REFERENCE HOUSE USED IN PARAMETRIC STUDY

GAS FURNACE WITH EXTERIOR CHIMNEY

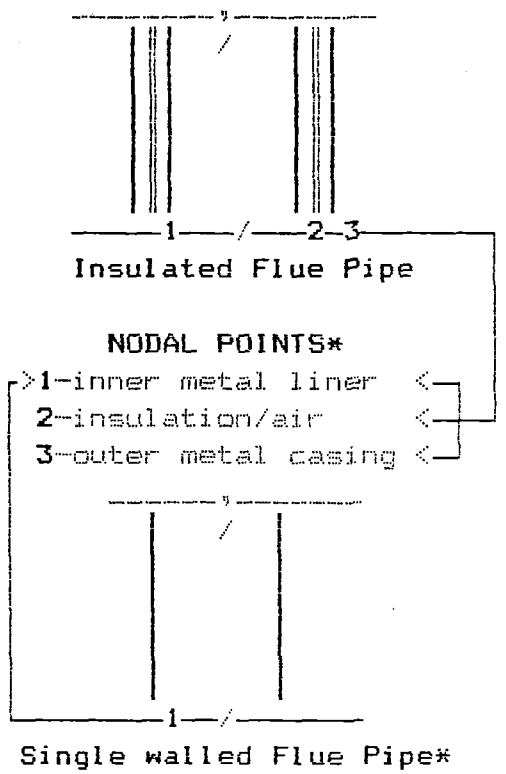


GAS FURNACE CHARACTERISTICS

OPENING AREAS:	-1-combustion air inlet	.0400	(m2)
	-2-outlet (breech)	.0110	(m2)
	-3-draft hood opening area	.0400	(m2)
OTHER DATA:	-4-interior chamber volume	.700	(m3)
	-5-heat exchanger's:-mass	35.0	(kg)
	-heat capacity	500	(W.s/kg.C)
	-firing rates-full on	29300	(W)
	-standby(pilot light)	350	(W)
	-steady state efficiency	77.0	(%)
	-steady state stack gas exhaust temp.	260.0	(C)



FLUE PIPE / VENT CONNECTOR



Open Area of the Flue Pipe	.0127	(m2)
Circumference or Perimeter		
1-inner metal liner	.399	(m)
2-insulation	0.000	(m)
3-outer metal casing	0.000	(m)
Element Thickness		
1-inner metal liner	.0005	(m)
2-insulation	0.0000	(m)
3-outer metal casing	0.0000	(m)
Densities		
1-inner metal liner	7900.0	(kg/m3)
2-insulation	0.00	(kg/m3)
3-outer metal casing	0.0	(kg/m3)
Heat Capacities		
1-inner metal liner	500.0	(W.s/kg.C)
2-insulation	0.0	(W.s/kg.C)
3-outer metal casing	0.0	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	8.30	(W/m2.C)
-points 2 and 3	0.00	(W/m2.C)
-points 3 and surrounding	0.00	(W/m2.C)

*For single walled flue pipe enter "0" for all entries of nodal points 2 & 3.

ENVELOPE

Airtightness Characteristics: -flow coefficient: C .03050 (m3/s.Pa^n)
(as defined by standard -flow exponent: n .720
CAN/CGSB-149.10-M) (non dimensional)

Maximum Exhaust Fan Flow Rate: 0.0 (L/s)

Maximum Fireplace Flow Rate: 0.0 (L/s)

AMBIENT TEMPERATURE AND WIND SPEED

Outdoor Temperature -10.0 (C)

Indoor Temperature 20.0 (C)

Wind Speeds: -horizontal 0.0 (m/s)

-vertical 0.0 (m/s)

(up is +)

INITIAL TEMPERATURES OF ELEMENTS

Initial Flue Temperatures: -flue gas 25.0 (C)

-nodal point #1 25.0 (C)

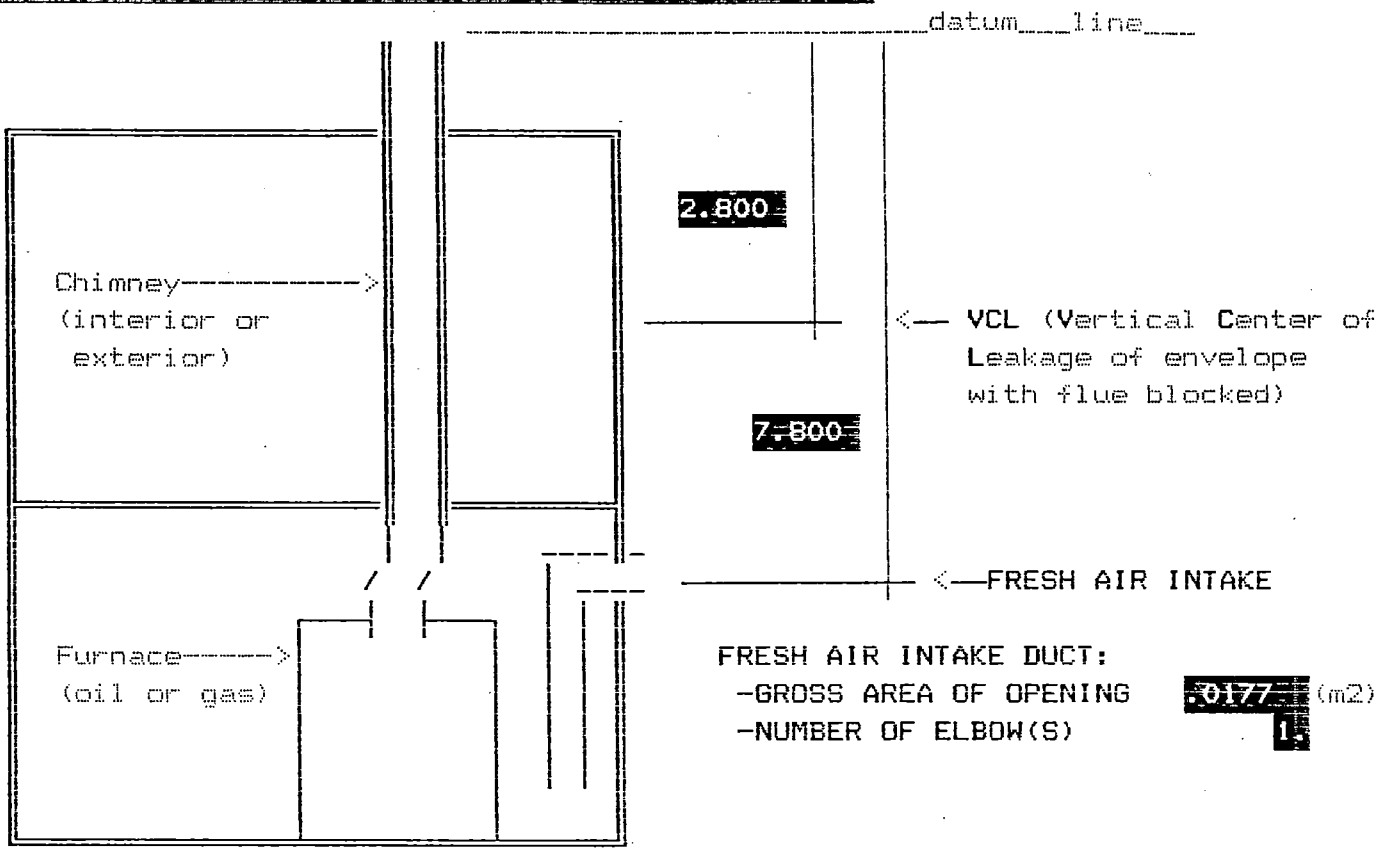
-nodal point #2 10.0 (C)

-nodal point #3 5.0 (C)

Initial furnace temperatures: -heat exchanger surface 32.0 (C)

-stack gas 32.0 (C)

VCL & FRESH AIR INTAKE LOCATION & CHARACTERISTICS



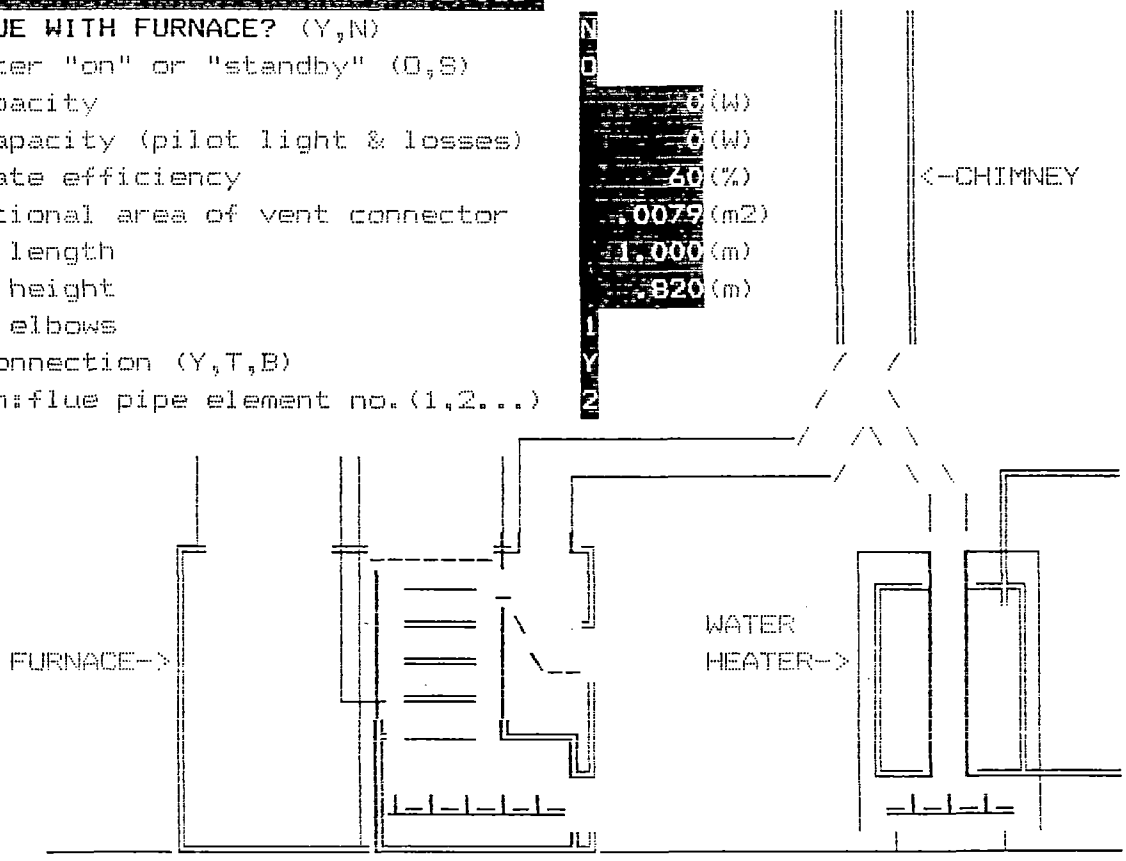
FRESH AIR INTAKE DUCT:

-GROSS AREA OF OPENING .0177 (m2)

-NUMBER OF ELBOW(S) 1

DOMESTIC HOT WATER HEATER CHARACTERISTICS

-SHARED FLUE WITH FURNACE? (Y,N)	N
-water heater "on" or "standby" (O,S)	O
-burner capacity	0 (W)
-standby capacity (pilot light & losses)	0 (W)
-steady state efficiency	60 (%)
-cross-sectional area of vent connector	.0079 (m2)
-flue pipe length	1.000 (m)
-flue pipe height	.820 (m)
-number of elbows	1
-type of connection (Y,T,B)	Y
-connection:flue pipe element no.(1,2...)	2



FLUE DAMPER AND FLUE CAP

FLUE DAMPER:

-Is there a flue damper? (Y,N)	Y
-Damper activation: thermal or electric? (T,E)	E
-Thermal activation temperature: -fully open	125 (°C)
-fully closed	35 (°C)
-Leakage area around flue damper when closed	.00033 (m2)

FLUE CAP:

-Horizontal wind pressure coefficient (horizontal wind pressure coefficient is needed even if 'Actual wind angle' below is not 0°)	.500
-Actual wind angle (measured from horizontal: + up, - down)	0.0 (°)
-Wind pressure coefficient at that angle	.500
-Wind speed at that angle	0.000 (m/s)
-Flue cap friction factor	

OPTIONAL SPECIFICATIONS

Furnace Thermostat Setting:

-thermostat setpoint 20.0 (°C)

-furnace thermostat band* 0.0 (°C)

House Thermal Characteristics:

-heated house volume 400.0 (m3)

-thermal conductivity of the house envelope 200.0 (W/°C)

-thermal mass of the house structure (L,M,or H)** L

Mechanical Draft Inducer:

-Do you wish to include a draft inducer in the vent connector? (Y/N) N

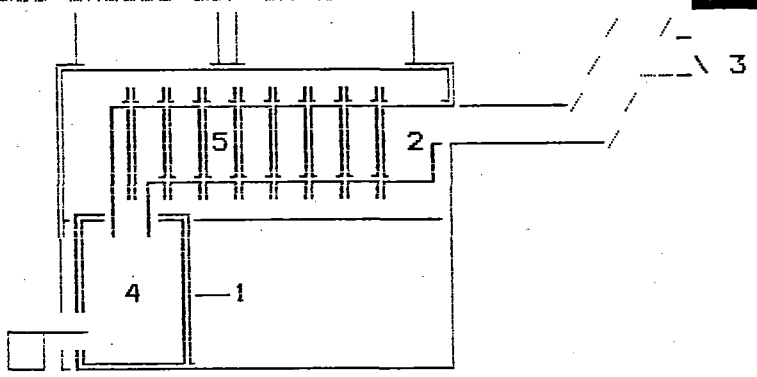
---

* -enter "0" if you want to specify the furnace ON & OFF times in TIME CONTROLS
-enter the number of degrees for the thermostat band to simulate the dynamic performance of the envelope/furnace/thermostat system, e.g."4.0"(C)

** enter "L" for ordinary wood frame structure, "M" for a wood frame house with interior mass e.g. brick, & "H" for a conc. block or solid masonry structure

OIL FURNACE CHARACTERISTICS

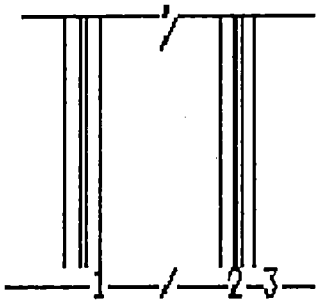
OPENING AREAS:	-1-firebox leakage area	.00150	(m2)
	-2-outlet (breech)	.0127	(m2)
	-3-damper-full open area	.0105	(m2)
	-% of above when closed (5-100%)	5.0	(%)
OTHER DATA:	-4-interior chamber volume	.700	(m3)
	-5-heat exchanger's:-mass	61.0	(kg)
	-heat capacity	500.0	(W.s/kg.C)
	-firing rates-full on	29300	(W)
	-standby(heat source)	0.0	(W)
	-steady state efficiency	75.0	(%)
	-steady state stack gas exhaust temperature	240.0	(C)
	-furnace excess air in %	130.0	(%)



APPENDIX D

DETAILS OF CHIMNEYS USED IN PARAMETRIC STUDY

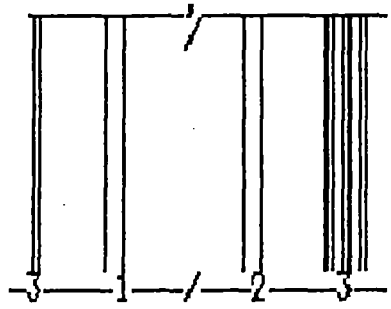
A-VENT CHIMNEY CHARACTERISTICS



NODAL POINTS
1-inner metal liner
2-insulation
3-outer metal casing

Open Area of the Flue	.0127	(m2)
Circumference or Perimeter		
1-inner metal liner	.399	(m)
2-insulation	.456	(m)
3-outer metal casing	.599	(m)
Element Thickness		
1-inner metal liner	.0003	(m)
2-insulation	.0250	(m)
3-outer metal casing	.0030	(m)
Densities		
1-inner metal liner	7830.0	(kg/m3)
2-insulation	384.0	(kg/m3)
3-outer metal casing	7830.0	(kg/m3)
Heat Capacities		
1-inner metal liner	500.0	(W.s/kg.C)
2-insulation	800.0	(W.s/kg.C)
3-outer metal casing	500.0	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	6.00	(W/m2.C)
-points 2 and 3	6.00	(W/m2.C)
-points 3 and surrounding	8.30	(W/m2.C)

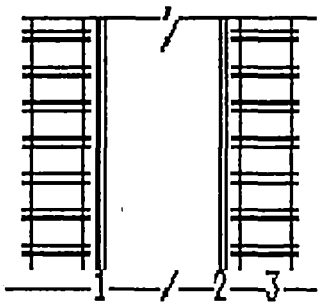
B-VENT CHIMNEY CHARACTERISTICS



NODAL POINTS
1-inner metal liner
2-outer metal casing
3-enclosing structure
(i.e. gypsum board)

Open Area of the Flue	.0127	(m2)
Circumference or Perimeter		
1-inner metal liner	.399	(m)
2-outer metal casing	.456	(m)
3-enclosing structure	.920	(m)
Element Thickness		
1-inner metal liner	.0003	(m)
2-outer metal casing	.0003	(m)
3-enclosing structure	.0158	(m)
Densities		
1-inner metal liner	2740.0	(kg/m3)
2-outer metal casing	7830.0	(kg/m3)
3-enclosing structure	1200.0	(kg/m3)
Heat Capacities		
1-inner metal liner	896.0	(W.s/kg.C)
2-outer metal casing	500.0	(W.s/kg.C)
3-enclosing stucture	1080.0	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	5.85	(W/m2.C)
-points 2 and 3	5.28	(W/m2.C)
-points 3 and surrounding	7.23	(W/m2.C)

MASONRY CHIMNEY CHARACTERISTICS



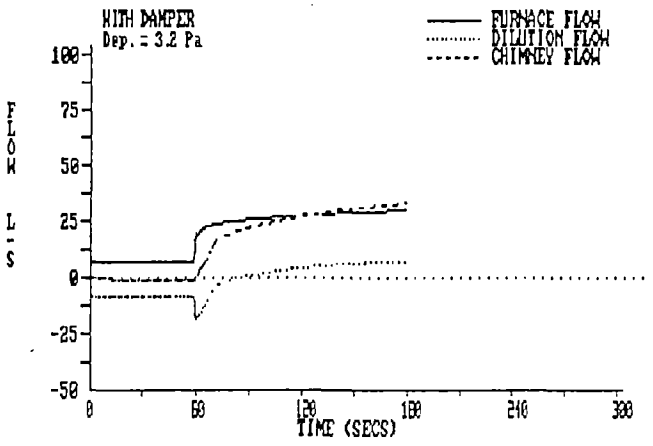
NODAL POINTS
1-inner half of clay liner
2-outer half of clay liner
3-masonry enclosure
(brick or other
masonry products)

Open Area of the Flue	.0240(m2)
Circumference or Perimeter	
1-inner half of liner	.667(m)
2-outer half of liner	.756(m)
3-masonry enclosure	1.078(m)
Element Thickness	
1-inner half of liner	.0110(m)
2-outer half of liner	.0110(m)
3-masonry enclosure	.0950(m)
Densities	
1-inner half of liner	1790.0(kg/m3)
2-outer half of liner	1790.0(kg/m3)
3-masonry enclosure	1970.0(kg/m3)
Heat Capacities	
1-inner half of liner	829.0(W.s/kg.C)
2-outer half of liner	829.0(W.s/kg.C)
3-masonry enclosure	800.0(W.s/kg.C)
Heat Loss Factors Between:	
-points 1 and 2	45.00(W/m2.C)
-points 2 and 3	4.00(W/m2.C)
-points 3 and surrounding	10.20(W/m2.C)

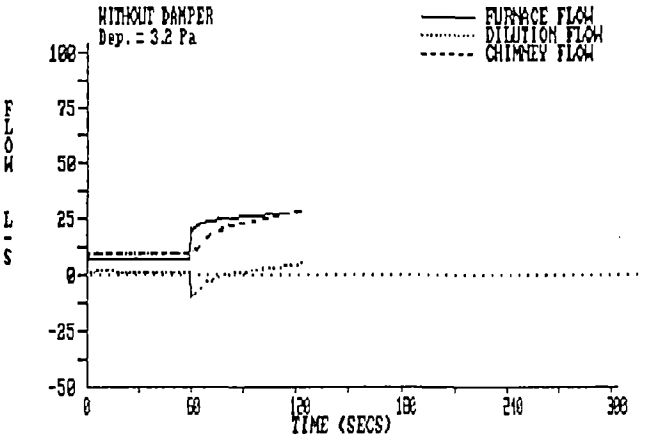
APPENDIX E

SIMULATIONS USED TO DETERMINE LEVEL OF DEPRESSURIZATION TO CAUSE IRREVERSIBLE BACKDRAFTING

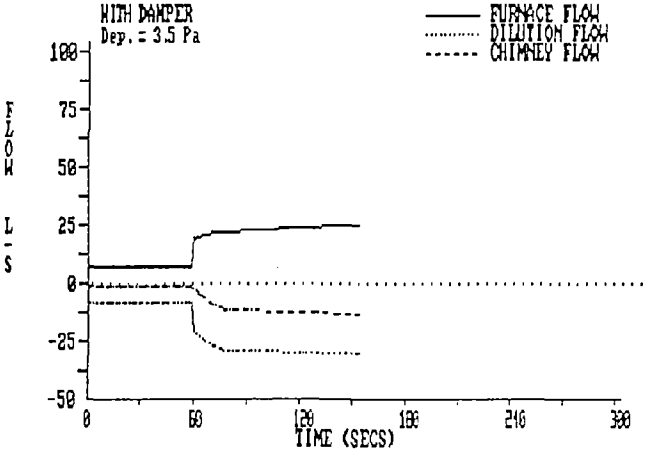
Spillage Profiles for Electrically-operated Damper
Installed in a Venting System With an Exterior B-vent



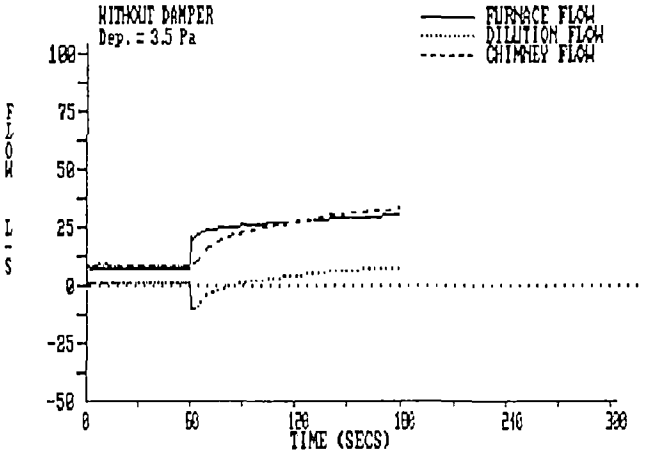
FLOW RATE vs. TIME



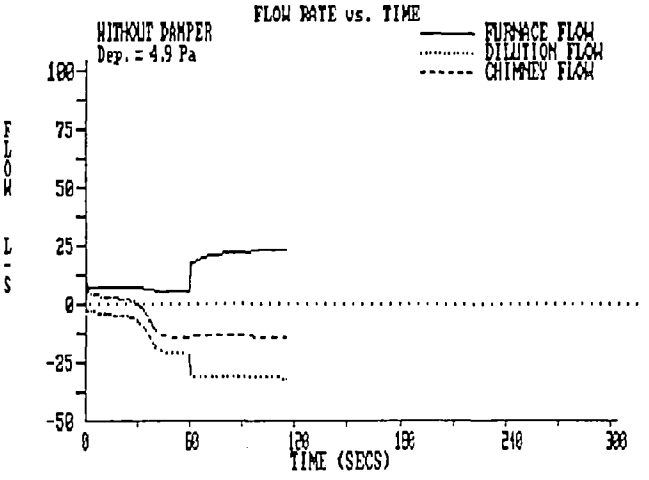
FLOW RATE vs. TIME



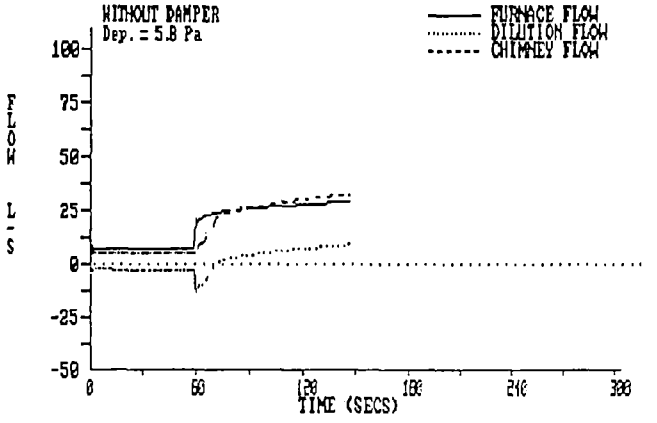
FLOW RATE vs. TIME



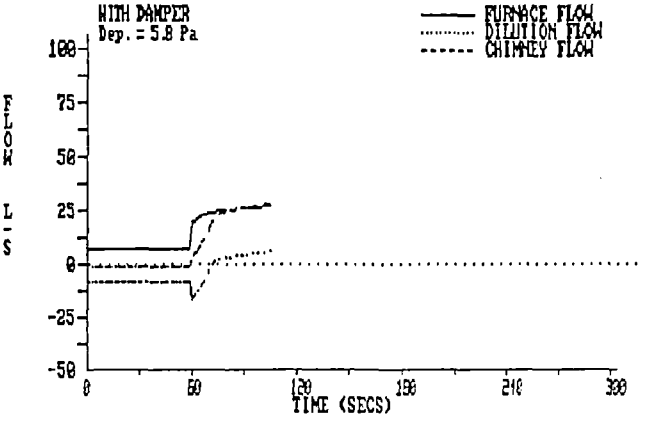
FLOW RATE vs. TIME



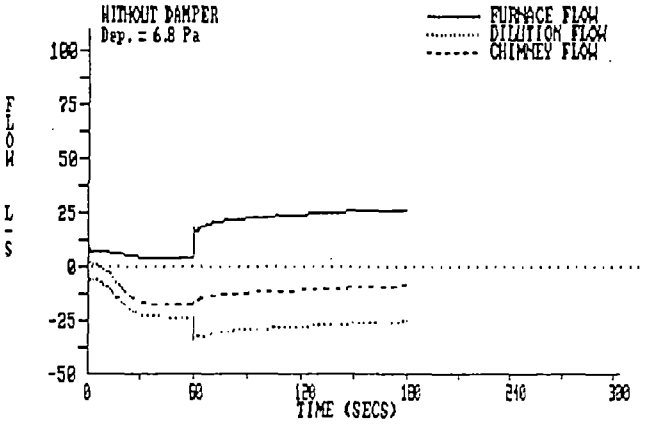
FLOW RATE vs. TIME



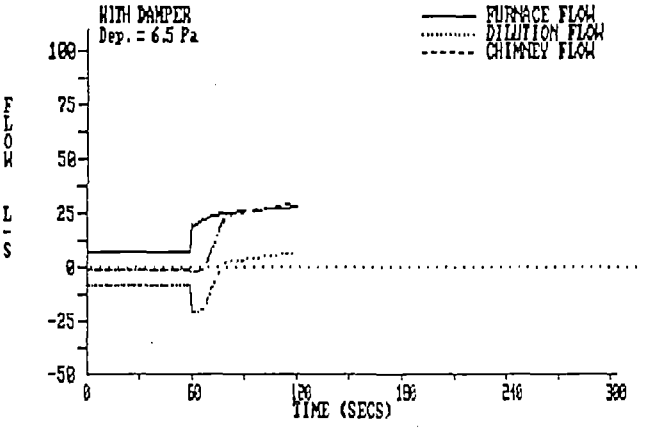
FLOW RATE vs. TIME



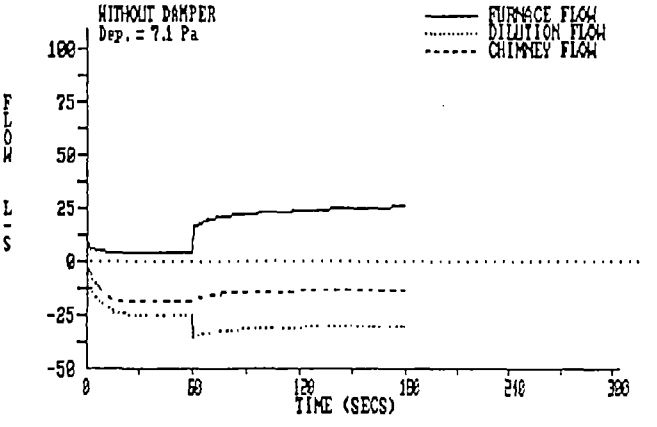
FLOW RATE vs. TIME



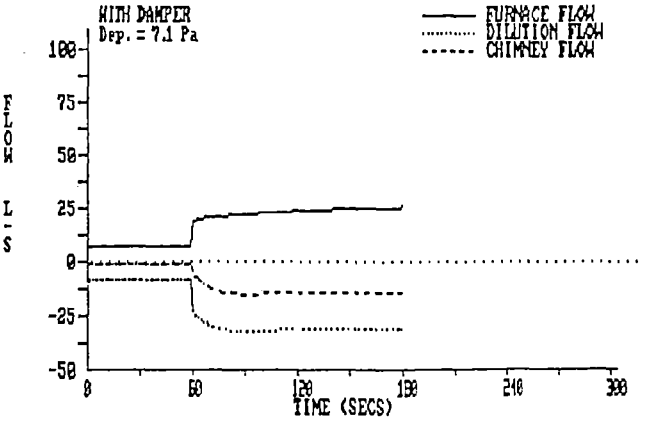
FLOW RATE vs. TIME



FLOW RATE vs. TIME



FLOW RATE vs. TIME



FLOW RATE vs. TIME

APPENDIX F

COMPARISON OF FLUE SIMULATOR PREDICTIONS WITH FIELD DATA

COMPARISON OF FLUE SIMULATOR PREDICTIONS WITH FIELD DATA

The objectives of comparing FLUE SIMULATOR's predictions with the results of the field tests on a furnace/flue system incorporating a damper were twofold:

1) To test the thermal damper algorithm used in the model both in the heat-up and cool-down phases of the furnace cycle.

2) To substantiate or, if necessary, revise the findings of the parametric study.

The field tests were conducted by Sheltair Scientific Ltd. on a gas furnace connected to an interior masonry chimney. The test conditions and details of the furnace, venting system and house are shown on the FLUE SIMULATOR input sheets in Appendix G. The complete test data are included as Appendix H.

The following tests were conducted:

- heat-up/cool-down with no damper
- heat-up/cool-down with damper
- sequential furnace on/furnace off tests with the damper installed
- furnace start-up test with a house depressurization of -6.5 Pa and the thermal damper installed.
- furnace start-up test with a house depressurization of -8 Pa and no thermal damper installed.
- furnace start-up test with a house depressurization of -8 Pa and the thermal damper installed.

The damper used in the test was an Ameritherm thermal damper. Outdoor temperature was 10°C under calm conditions.

THE INFLUENCE OF FLUE DAMPERS ON THE VENTING PERFORMANCE OF FLUES

Sheltair was able to collect a large amount of data during these field tests including:-

- furnace exit temperatures,
- flue gas temperatures upstream and downstream of the thermal damper,
- chimney bottom temperatures,
- chimney exit temperatures,
- vent connector flow rate and,
- flue pipe liner temperatures.

The approach adopted for this phase of the work consisted of two main tasks:-

- analysis of field data
- comparison of the field results to the simulated results.

SUMMARY OF FIELD RESULTS

The field results relevant to this phase of the project were the heat-up/cool-down tests with and without a damper installed. These results are summarized graphically in Figure F.1. The flue gas temperature shown in these figures was measured downstream of the thermal damper location.

With the thermal damper installed, the flue gas temperature during the heat-up portion of the furnace cycle was slightly warmer than without a damper. At the end of the furnace cycle, the maximum flue gas temperature with the damper installed was 222°C whereas, without the damper, the temperature reached a maximum of 214°C. The flue gas temperature profiles are shown in Figure F.1a. Exit temperatures, however, were consistently

cooler with the damper installed than without. These results are shown in Figure F.1b.

The differences between the two tests are small, indicating that the damper opens extremely quickly. The difference in flue gas temperatures between the dampered and non-dampered tests is probably attributed to a small added friction effect caused by the presence of the damper which would reduce the dilution air flow component slightly. The net effect would be a reduction in the chimney flow rate (compared to the non-dampered case) and the field flow data substantiates this (see Figure F.2).

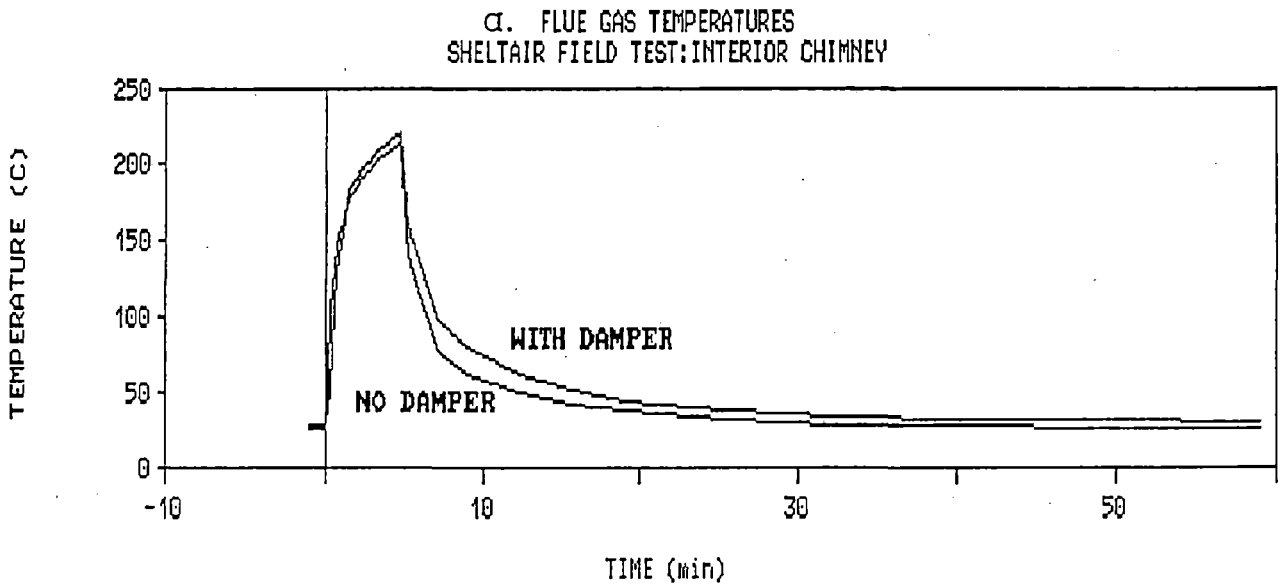
Thus, the field results indicate that the presence of a thermal damper has little effect on the heat-up portion of the furnace cycle when installed on an interior masonry chimney.

During the cool-down phase of the furnace cycle, the flue gas temperature in the dampered chimney remained warmer than the flue gas temperature in the non-dampered chimney (see Figure F.1a). This is due to two phenomena. First, when the damper closes, the flue can handle less flow and, depending on available draft, its flow capacity may be less than the flow emanating from the furnace heat exchanger (which consists of warm air and the products of combustion from the pilot light). In these circumstances, some part of this flow will spill out of the furnace dilution port, thus eliminating the flow of cooler room air into the dilution port and up the flue. Second, there is less total flow up the flue than is the case for a non-dampered chimney so that, for a given amount of heat retained in the flue liner, the equilibrium temperature of that flow will be higher and the temperature of the flue liner will decay more slowly.

Exit temperatures were marginally cooler in the dampered chimney than in the non-dampered chimney.

Not surprisingly, the flow rates in the dampered chimney were much lower (due to the decreasing flow area as the damper closed) than in the non-dampered case throughout the full cool-down portion of the cycle. At steady state (30 minutes after furnace shutdown) the flow rate in the dampered chimney was virtually 0 L/s versus 10 L/s in the non-dampered chimney case. These results are shown in Figure F.2.

The overall effect on the theoretical draft appears to be small (using average flue gas temperature as a proxy for theoretical draft). This is consistent with the results of the parametric study reported in Appendix B.



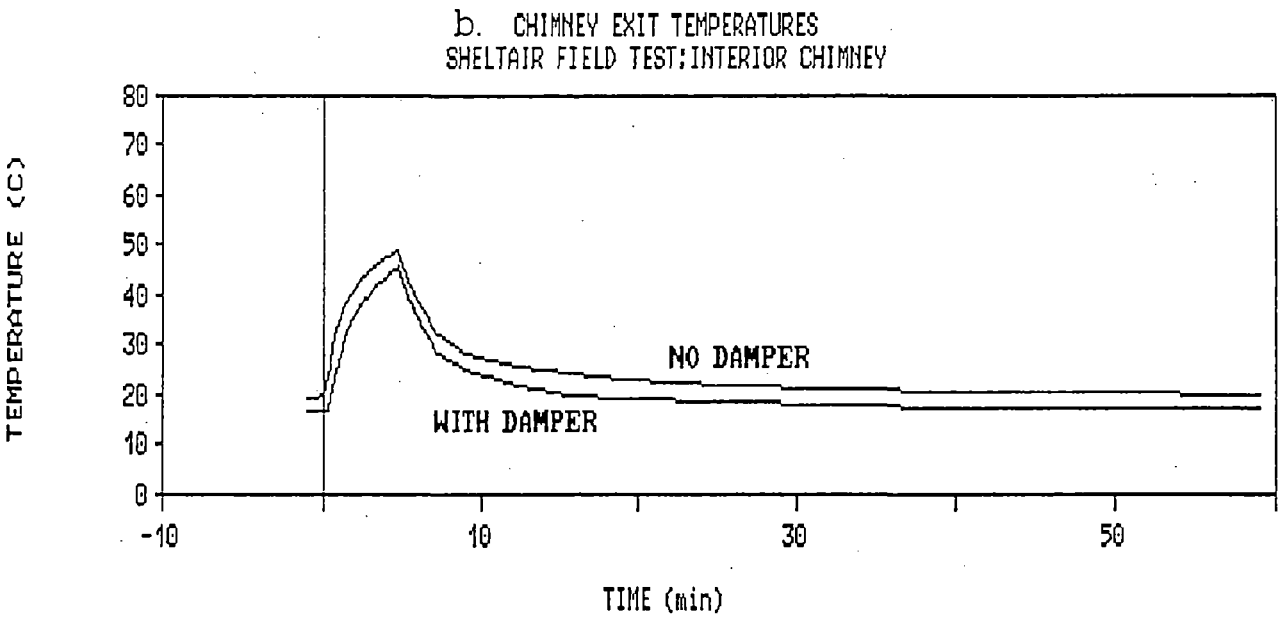


FIGURE F.1: Comparison of flue gas temperatures measured in the field for an interior masonry chimney with and without a thermal damper.

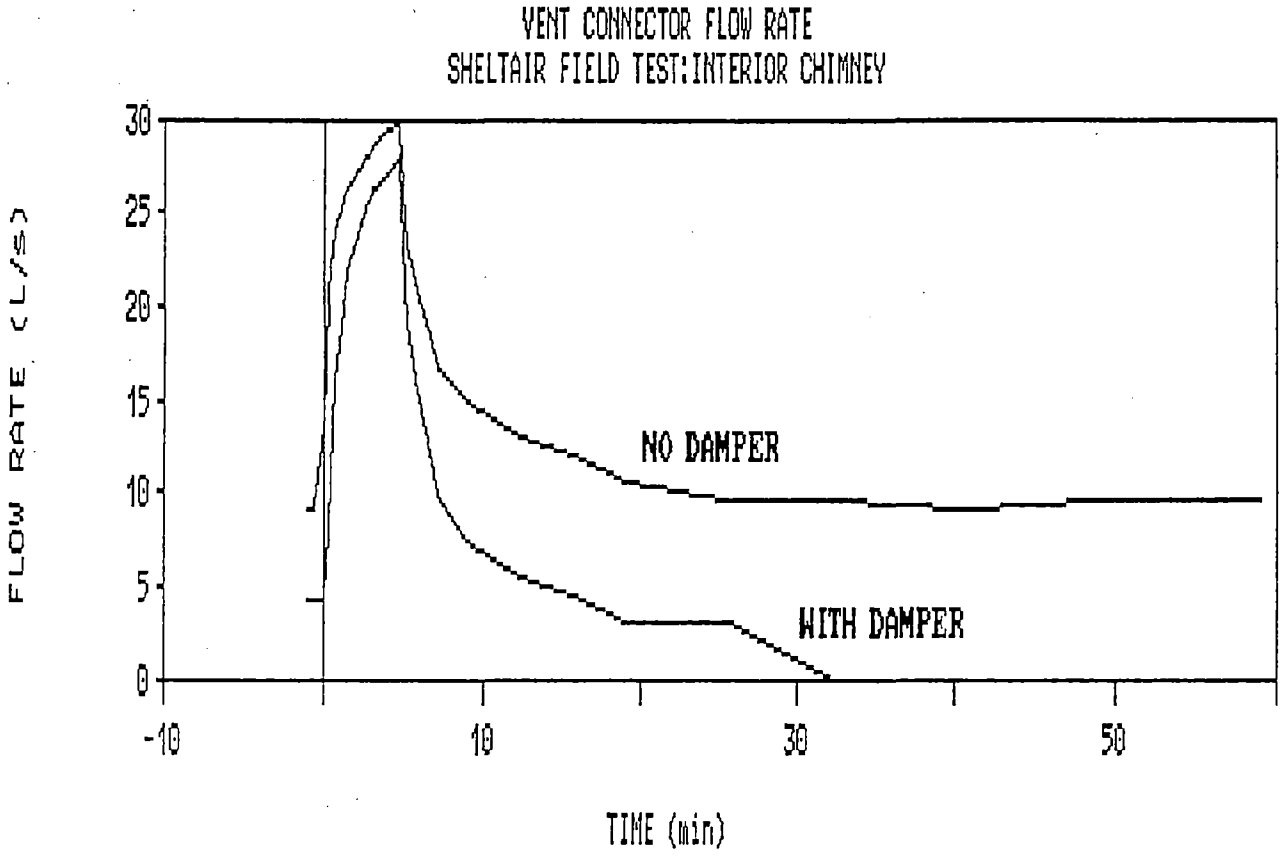


Figure F.2: Comparison of vent connector flow rates measured in the field for an interior masonry chimney with and without a thermal damper.

COMPARISON OF SIMULATION RESULTS AND FIELD DATA

The first step in making detailed comparisons between the model's predictions and Sheltair's field results was to look at comparisons for the non-dampered chimney. This strategy was adopted because, except for the latest modifications (including the damper modelling modifications), FLUE SIMULATOR had already been extensively calibrated against field data. Thus, discrepancies showing up at this stage would likely indicate errors in the input data describing the house/furnace/flue system rather than errors in the model. Once these data were known to be correct, it would then be possible to continue with testing of the damper modelling modifications and know that discrepancies arising then would likely be modelling errors rather than input errors.

This proved to be a good strategy because initial comparisons were not very good. A review of the input data provided by Sheltair indicated that the furnace outlet area was substantially larger than industry norms. When a furnace outlet area consistent with industry norms was substituted for the furnace outlet area in the FLUE SIMULATOR inputs, much better agreement with field data was achieved. The reasons for the discrepancy between the model's predictions based on the reported furnace outlet area and the field data is not clear at this time. One can only speculate that there are some internal restrictions in the heat exchanger outlet paths not visible from the outside. Suffice it to say that modifying the reported furnace outlet area to be consistent with industry norms results in good agreement with field results. These comparisons are reported here.

The initial comparison was between the furnace exit temperatures predicted by the model and field measurements for the non-dampered chimney. The comparison yielded an extremely good match throughout a major portion of the simulation. At steady state

after cool-down the predicted furnace exit temperatures was 13°C lower than observed in the field. This may be due to the fact that at standby the pilot light is probably concentrated in only one of the three outlet ports. The temperature sensor was probably measuring this concentrated effect. The model however, outputs a mean temperature based on the total flow. Thus, a difference of 10°C to 15°C between predicted and measured results is not surprising. These comparisons are shown in Figure F.3.

An excellent match of the flue gas temperature just downstream of the dilution port was achieved over the heat-up portion of the furnace cycle. Maximum difference when the furnace was shut off was only 3°C. These results are shown in Figure F.4a.

The predicted chimney exit temperature was much higher than the field result. When the furnace was shut off, the chimney exit temperature in the field was 49°C whereas the model predicted 74°C. These results are shown in Figure F.4b.

The model also matched the flow rates measured in the field very well. Maximum variation was for just before furnace shut-off. For that time, the model predicted a flow rate of 32 L/s and the field result was 30 L/s. The difference is approximately 10%. This profile is shown in Figure F.5.

For the cool-down portion of the furnace cycle, the model matched the field flue gas and exit temperatures remarkably well. Predicted flow rates were approximately 5-10% above the field results.

Based on the model's overprediction of flow rates and the large inconsistency between predicted and measured chimney exit temperatures it is speculated that there may be leakage through the flue liner. If such were the case, dilution air would be

leaking into the chimney downstream of the flow measuring device resulting in a lower field flow rate measurement. The variations would be exacerbated at higher draft such as occurs during the heat-up portion and first few minutes of cool-down of the furnace cycle thus providing a possible explanation of the model's better match of the cool-down portion of the furnace cycle.

Because of the possibility that the input data might not reflect the actual integrity of the chimney liner, the results of the simulation of the chimney with a thermal damper were compared against the field results taking into account the potential differences between field and modelled results that may be a result of liner leakage.

The comparison between the simulation and field results for the dampered chimney are shown in Figure F.6 and Figure F.7. The graphs show that the model matches the field results reasonably well during the heat-up portion of the furnace cycle, indicating that the current algorithm for modelling the opening of the damper is adequate. The maximum variation in flue gas temperatures, 4°C, was for just before furnace shut-off.

Again, chimney exit temperatures during heat-up predicted by the model were much higher than observed in the field.

Flow rates predicted by the model were consistently higher than measured in the field during the heat-up portion of the furnace cycle. The flow just before furnace shut-off was measured at 28 L/s whereas the model predicted a flow rate of 32 L/s, a difference of approximately 15%.

The flue gas temperature predicted by the model for the first five minutes of the cool-down portion of the furnace cycle was greater than field measurements. For the remainder of the cool-

down, the predicted flue gas temperature was lower than the field result. This behaviour is an indication that the damper is closing faster than actually occurs in the field. Comparison of the predicted flow rates with the measured results substantiates this fact.

As with the non-dampered chimney, the predicted exit temperatures matched the field results very well during the cool-down portion of the furnace cycle.

Again, chimney liner leakage would explain the difference between the simulation and field results, especially the chimney exit temperature.

Thus, the comparison of the FLUE SIMULATOR predictions to actual field measurements indicates that the current algorithms used to model the opening of the damper are appropriate. One area which could be refined is the modelling of the closing portion of the damper cycle, which is currently too fast. This might be achieved by specifying a relationship between damper flow area and flue gas temperature during cool-down that is different than the heat-up relationship. This approach is appropriate for phenomena which display hysteresis - an effect likely to be present in the opening and the closing of thermal dampers.

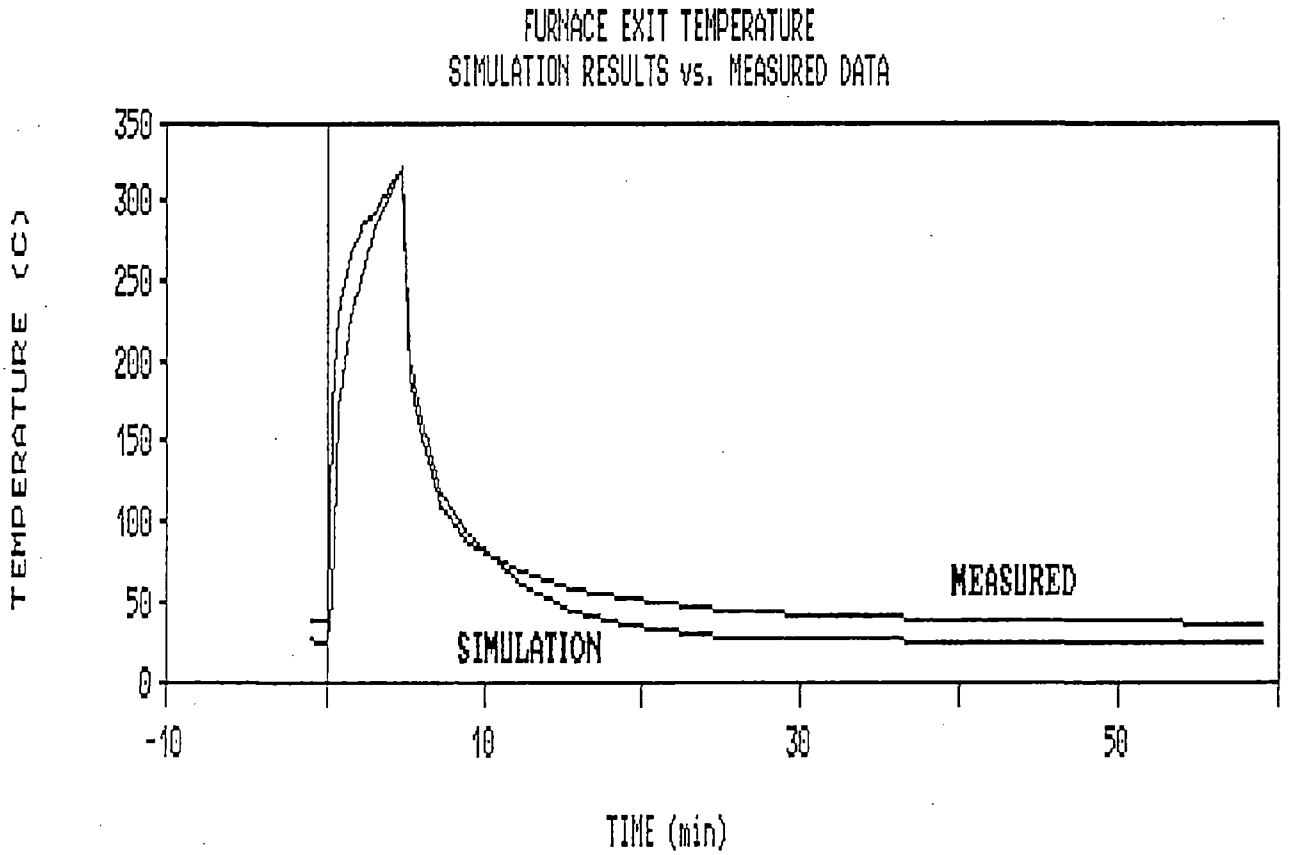
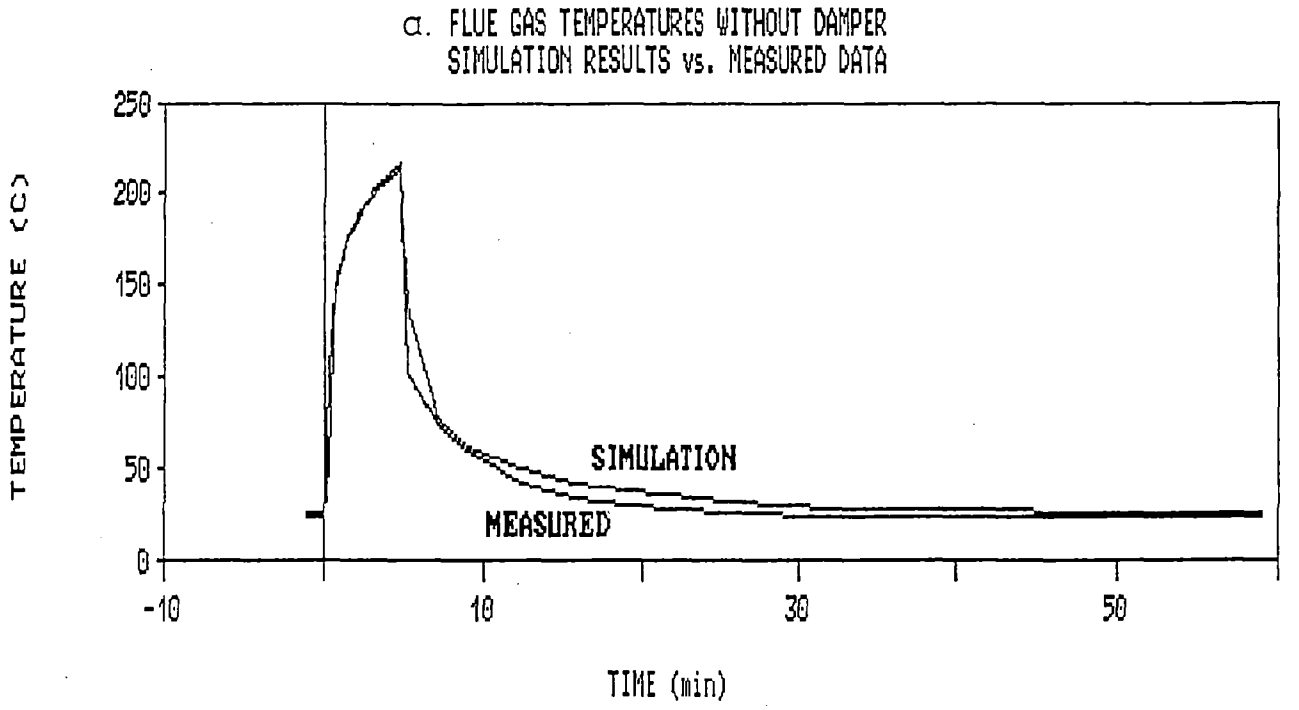


FIGURE F.3: Comparison of field and predicted furnace exit temperatures for an interior masonry chimney without a thermal damper.



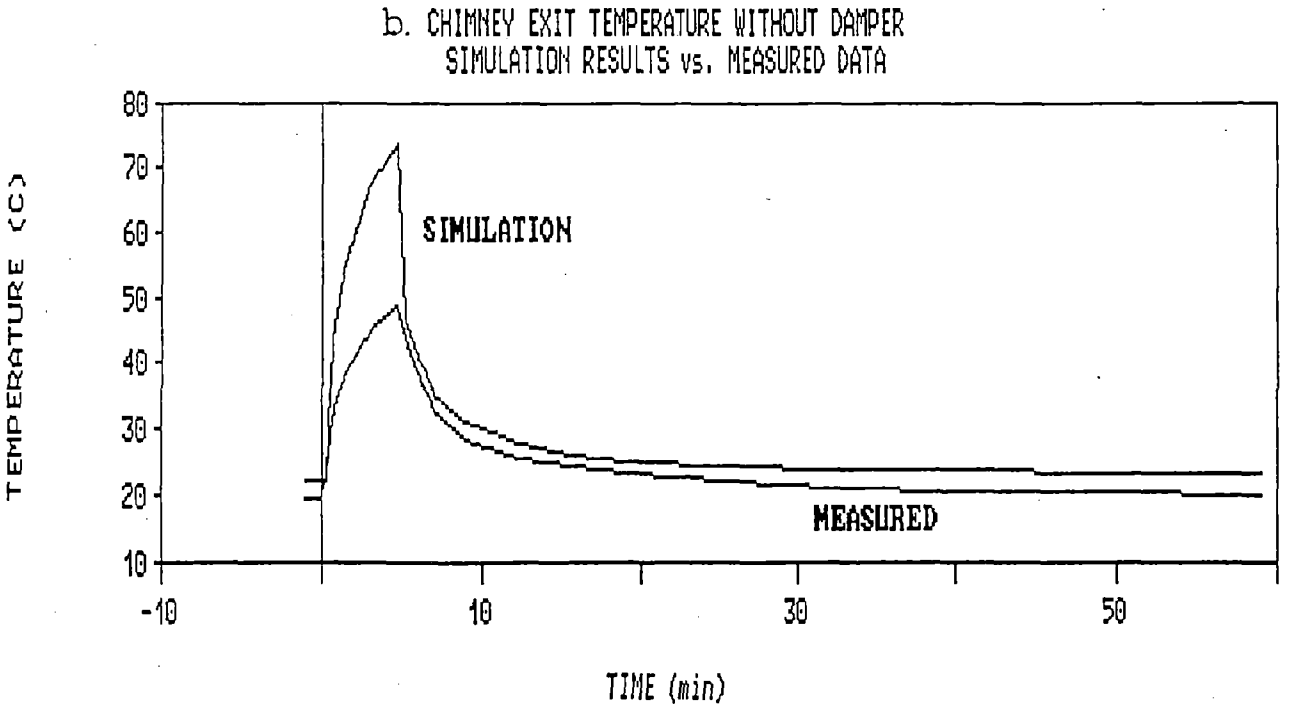


FIGURE F.4: Comparison of measured and predicted flue gas temperatures for an interior masonry chimney without a thermal damper.

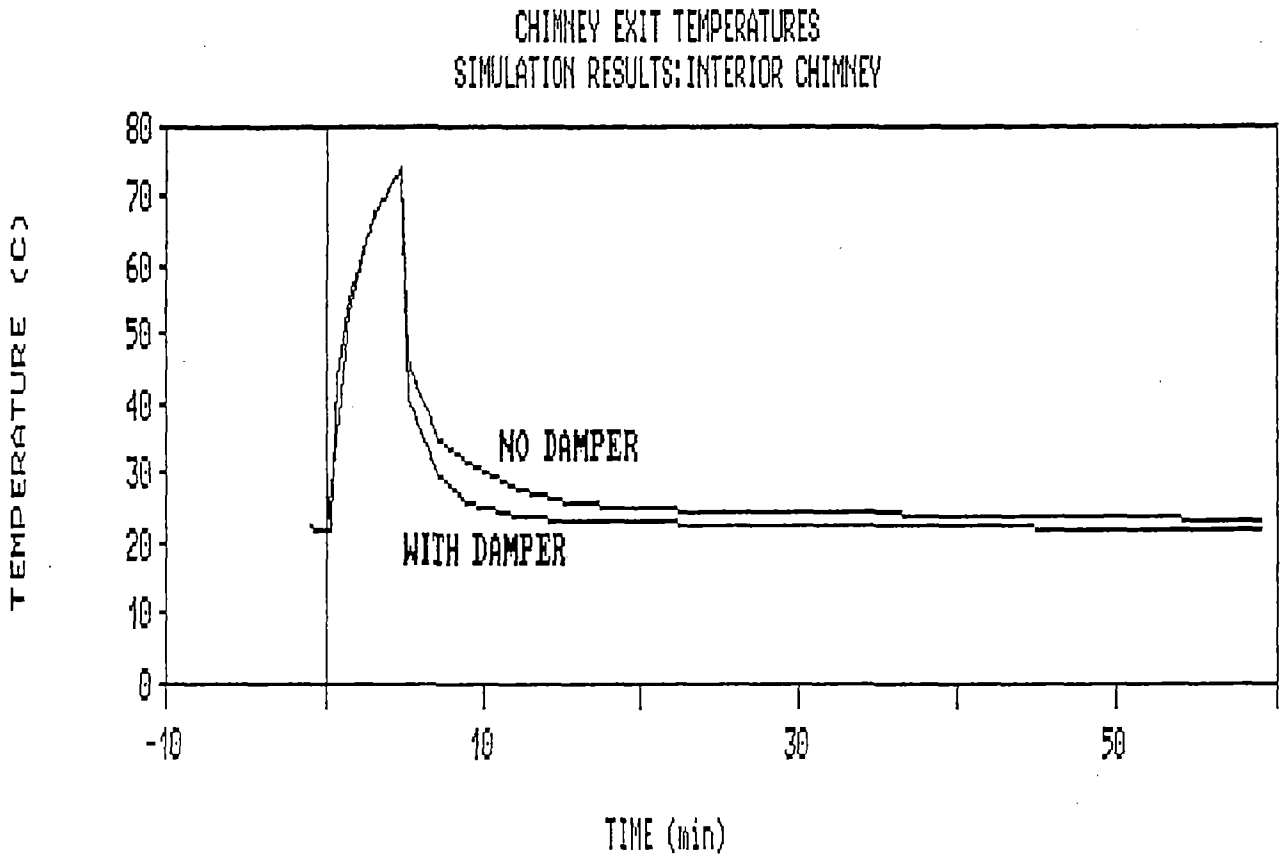
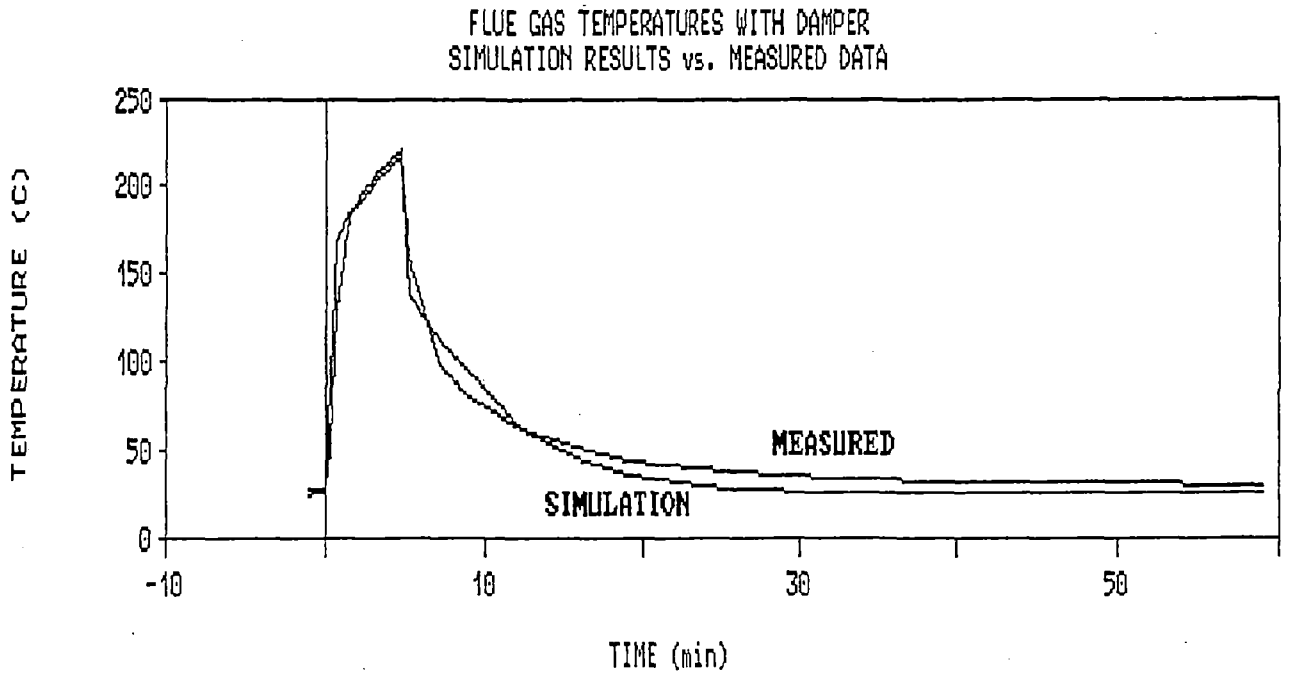


FIGURE F.5: Comparison of field and predicted chimney flow rates for an interior masonry chimney without a thermal damper.



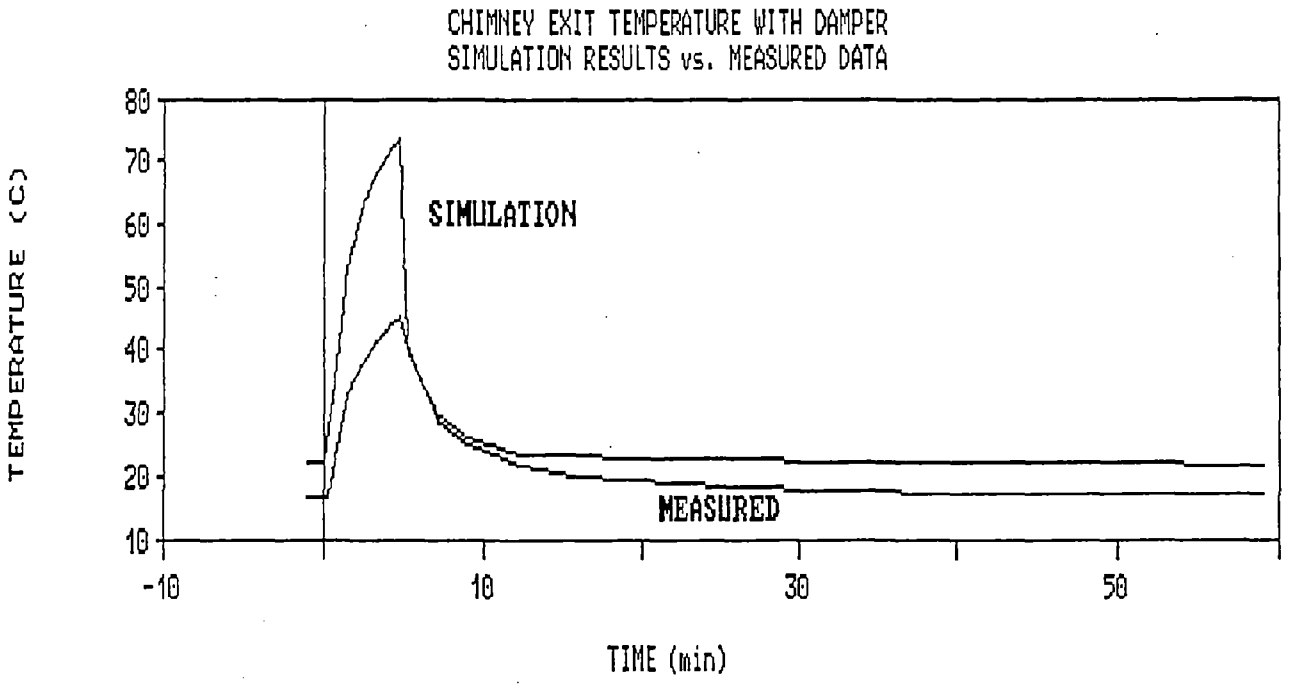


FIGURE F.6: Comparison of field and predicted flue gas temperatures for an interior masonry chimney with a thermal damper.

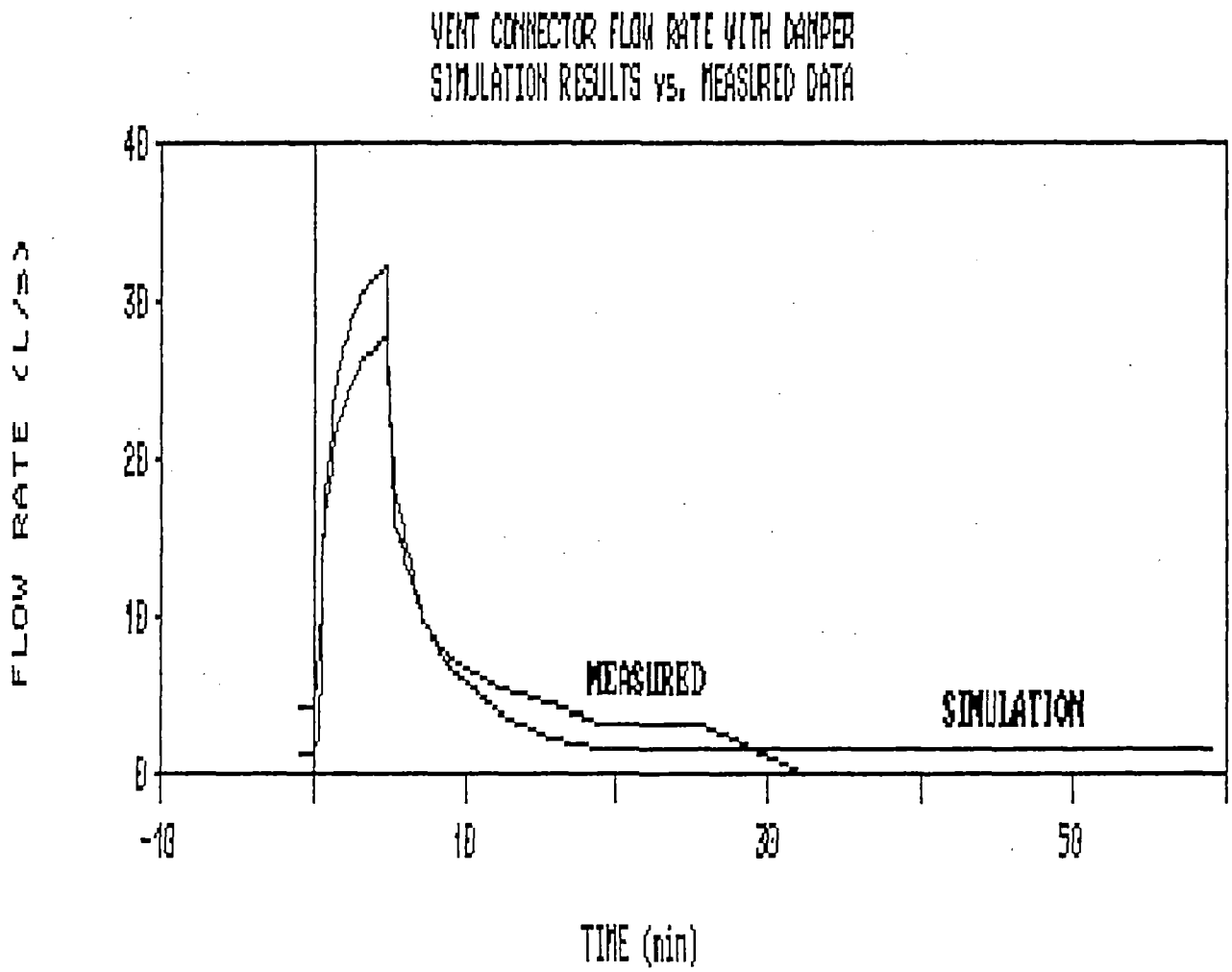
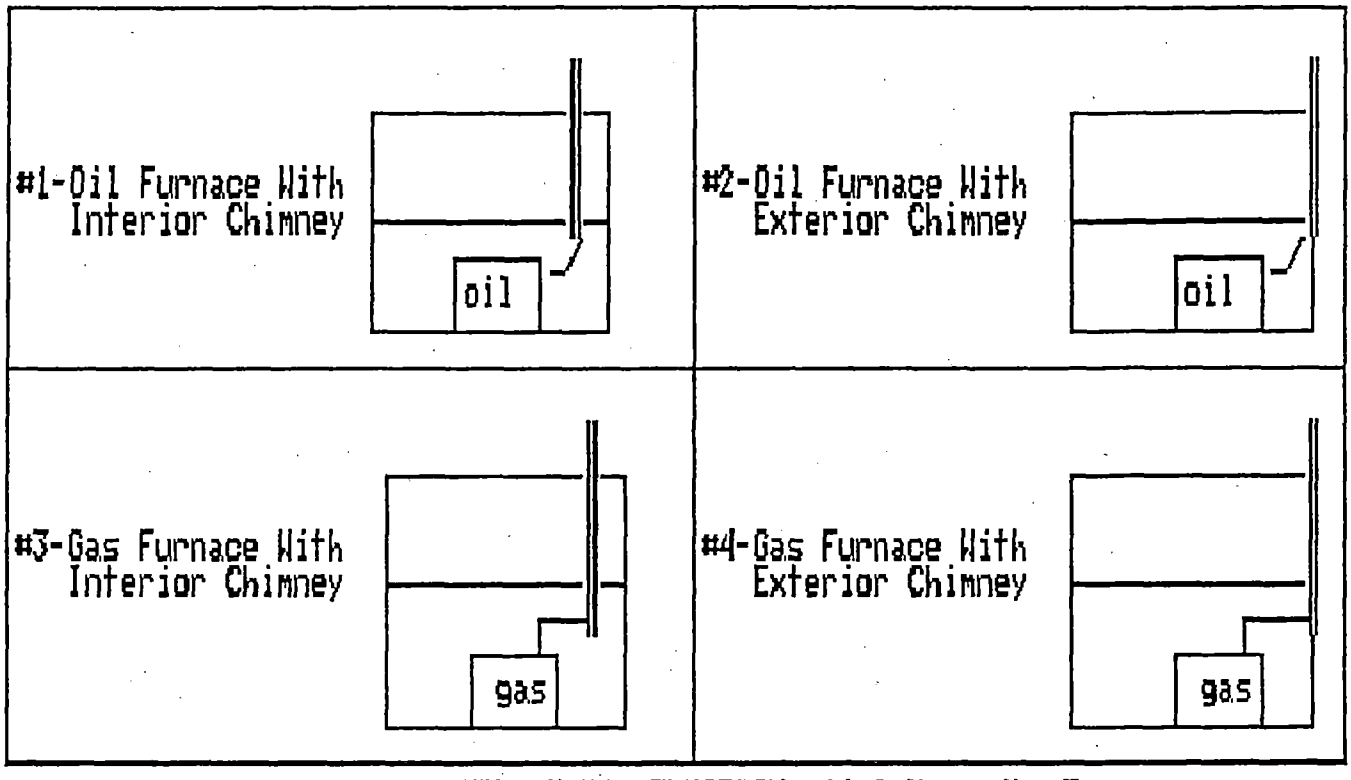


FIGURE F.7: Comparison of field and predicted chimney flow rates for an interior masonry chimney with a thermal damper.

APPENDIX G

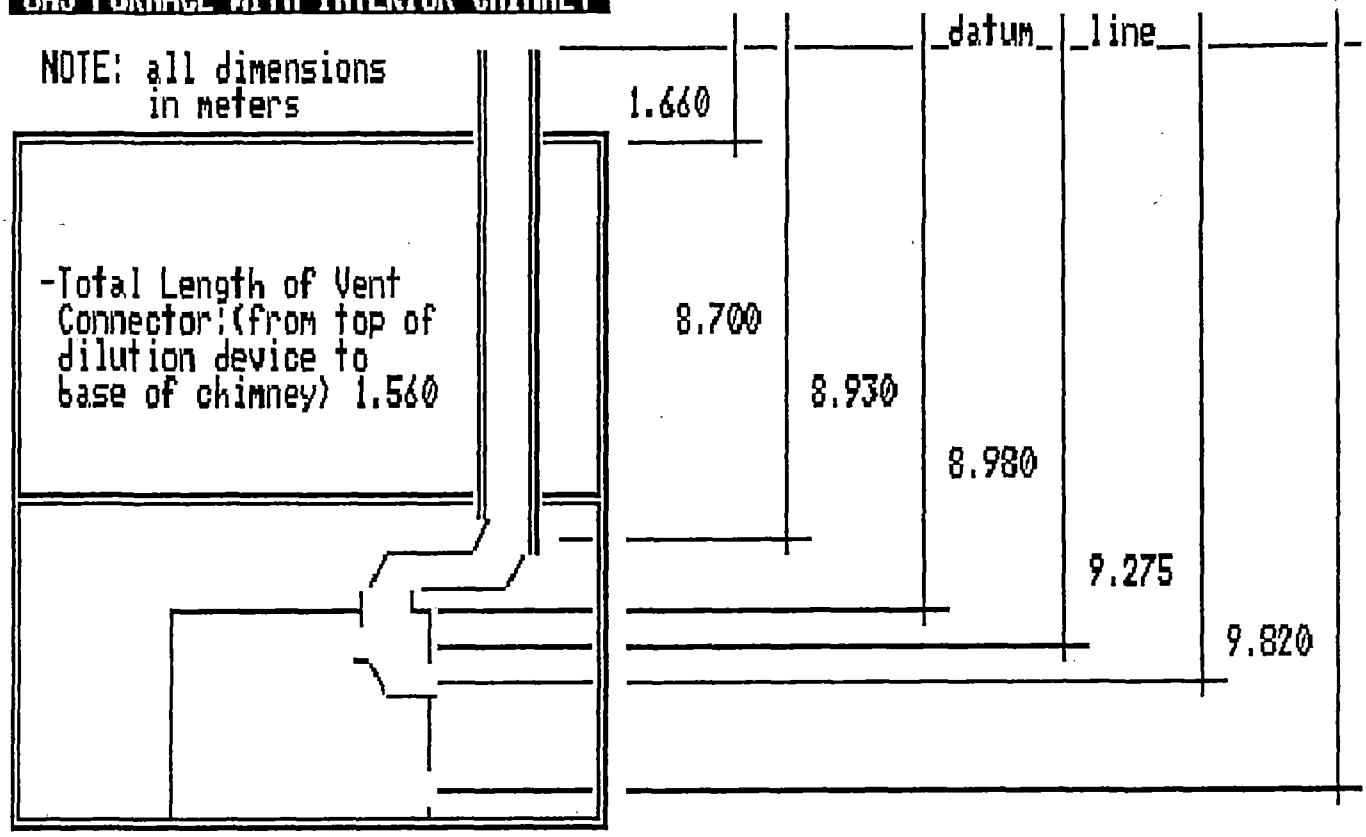
INITIAL CONDITIONS AND ENVELOPE AND FURNACE DETAILS OF HOUSE USED IN SHELTAIR TESTS

FUEL TYPE AND CHIMNEY LOCATION SELECTION



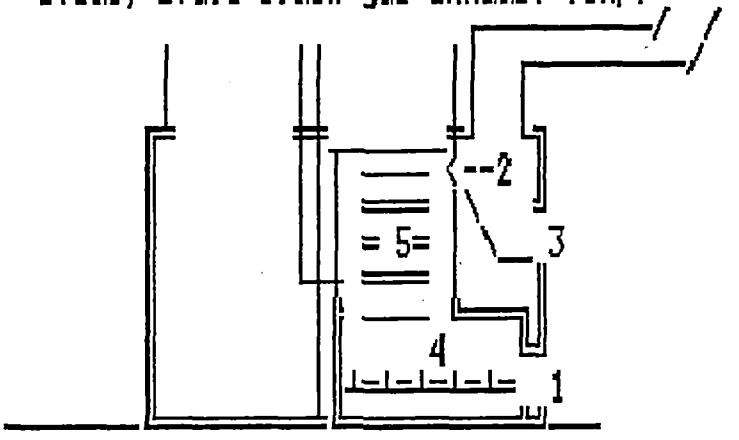
ENTER YOUR SELECTION #(1,2,3 or 4): 3

GAS FURNACE WITH INTERIOR CHIMNEY



GAS FURNACE CHARACTERISTICS

OPENING AREAS:	-1-combustion air inlet	.0266	(m2)
	-2-outlet (total of all exhaust ports)	.0117	(m2)
	-3-draft hood opening area	.0740	(m2)
OTHER DATA:	-4-interior chamber volume	.800	(m3)
	-5-heat exchanger's:-mass	35.0	(kg)
	-heat capacity	500.	(W.s/kg.C)
	-firing rates-full on	29308.	(W)
	-standby(pilot light)	322.	(W)
	-steady state efficiency	74.0	(%)
	-steady state stack gas exhaust temp.	360.0	(C)



FLUE PIPE CHARACTERISITCS

HOW MANY 45 deg. ELBOWS IN THE FLUE PIPE OR VENT CONNECTOR

(ENTER 2 FOR EACH 90 deg. ELBOW. ADD 2.5 FOR A TEE SECTION)

DEFAULT VALUE IS 6

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

TOTAL NUMBER OF STRAIGHT SECTIONS FROM TOP OF DILUTION DEVICE TO CHIMNEY BOTTOM

INPUT NUMBER OF SEGMENTS

DEFAULT VALUE IS 3

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 1

INPUT THE RISE OF THIS SECTION(in m)

DEFAULT VALUE IS 0.13000

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 1

INPUT THE LENGTH OF THIS SECTION(in m)

DEFAULT VALUE IS 0.44000

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 2

INPUT THE RISE OF THIS SECTION(in m)

DEFAULT VALUE IS 0.05000

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 2

INPUT THE LENGTH OF THIS SECTION(in m)

DEFAULT VALUE IS 0.56000

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 3

INPUT THE RISE OF THIS SECTION(in m)

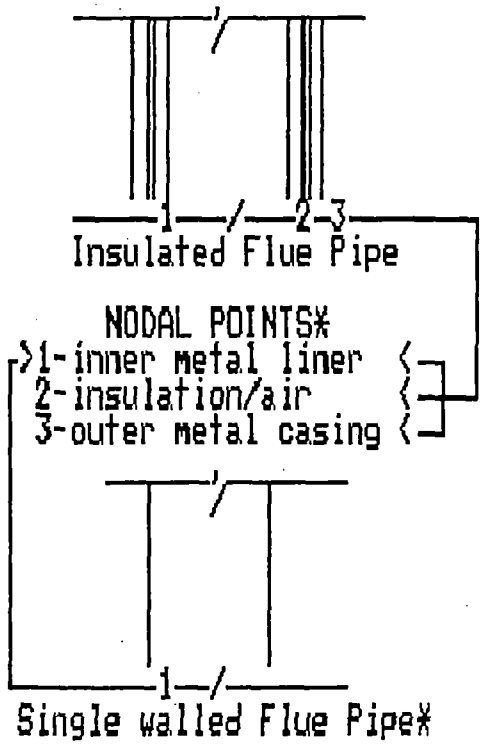
DEFAULT VALUE IS 0.05000

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

```
FLUE PIPE CHARACTERISITCS

SECTION  3

INPUT THE LENGTH OF THIS SECTION(in m)

DEFAULT VALUE IS     0.56000

        INPUT YOUR SELECTION -> ?

                                        HIT ENTER KEY TO USE DEFAULT
```

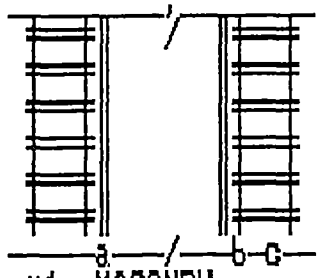
FLUE PIPE / VENT CONNECTOR



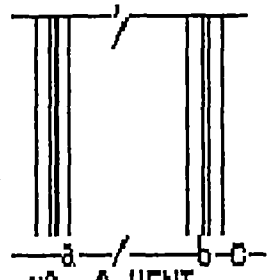
Open Area of the Flue Pipe	.0123	(m2)
Circumference or Perimeter		
1-inner metal liner	.393	(m)
2-insulation	0.000	(m)
3-outer metal casing	0.000	(m)
Element Thickness		
1-inner metal liner	.0005	(m)
2-insulation	0.0000	(m)
3-outer metal casing	0.0000	(m)
Densities		
1-inner metal liner	7830.0	(kg/m3)
2-insulation	0.00	(kg/m3)
3-outer metal casing	0.0	(kg/m3)
Heat Capacities		
1-inner metal liner	500.0	(W.s/kg.C)
2-insulation	0.0	(W.s/kg.C)
3-outer metal casing	0.0	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	8.33	(W/m2.C)
-points 2 and 3	0.00	(W/m2.C)
-points 3 and surrounding	0.00	(W/m2.C)

*For single walled flue pipe enter "0" for all entries of nodal points 2 & 3.

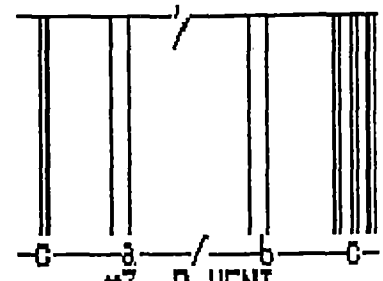
CHIMNEY TYPES STUDY THE FOUR CHIMNEY SECTIONS BELOW AND SELECT THE TYPE THAT BEST DESCRIBES THE CHIMNEY YOU WANT TO MODEL



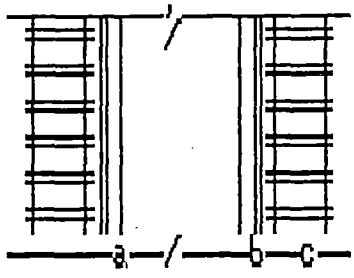
#1 MASONRY
a-clay flue liner
b-air space
c-masonry enclosure



#2 A-VENT
a-inner metal liner
b-insulated cavity
c-outer metal casing



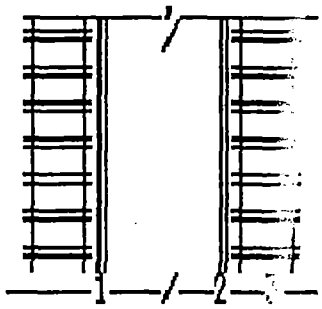
#3 B-VENT
a-inner metal liner
b-outer metal casing
c-enclosing structure



4 MASONRY WITH METAL FLUE LINER
a-metal flue liner
b-clay flue liner
c-masonry enclosure

ENTER YOUR SELECTED CHIMNEY TYPE #1

MASONRY CHIMNEY CHARACTERISTICS



NODAL POINTS
1-inner half of clay liner
2-outer half of clay liner
3-masonry enclosure
(brick or other
masonry products)

Open Area of the Flue	.0256	(m2)
Circumference or Perimeter		
1-inner half of liner	.640	(m)
2-outer half of liner	.904	(m)
3-masonry enclosure	1.330	(m)
Element Thickness		
1-inner half of liner	.0165	(m)
2-outer half of liner	.0165	(m)
3-masonry enclosure	.1070	(m)
Densities		
1-inner half of liner	1790.0	(kg/m3)
2-outer half of liner	1790.0	(kg/m3)
3-masonry enclosure	1970.0	(kg/m3)
Heat Capacities		
1-inner half of liner	829.0	(W.s/kg.C)
2-outer half of liner	829.0	(W.s/kg.C)
3-masonry enclosure	800.0	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	60.60	(W/m2.C)
-points 2 and 3	4.70	(W/m2.C)
-points 3 and surrounding	5.10	(W/m2.C)

ENVELOPE

Airtightness Characteristics:	-ELA (equiv. leakage area)	.031	(m2)
(as defined by standard CAN/CGSB-149.10-M)	-flow exponent: n (non dimensional)	.670	
Maximum Exhaust Fan Flow Rate:		0.0	(L/s)
Maximum Fireplace Flow Rate:		0.0	(L/s)

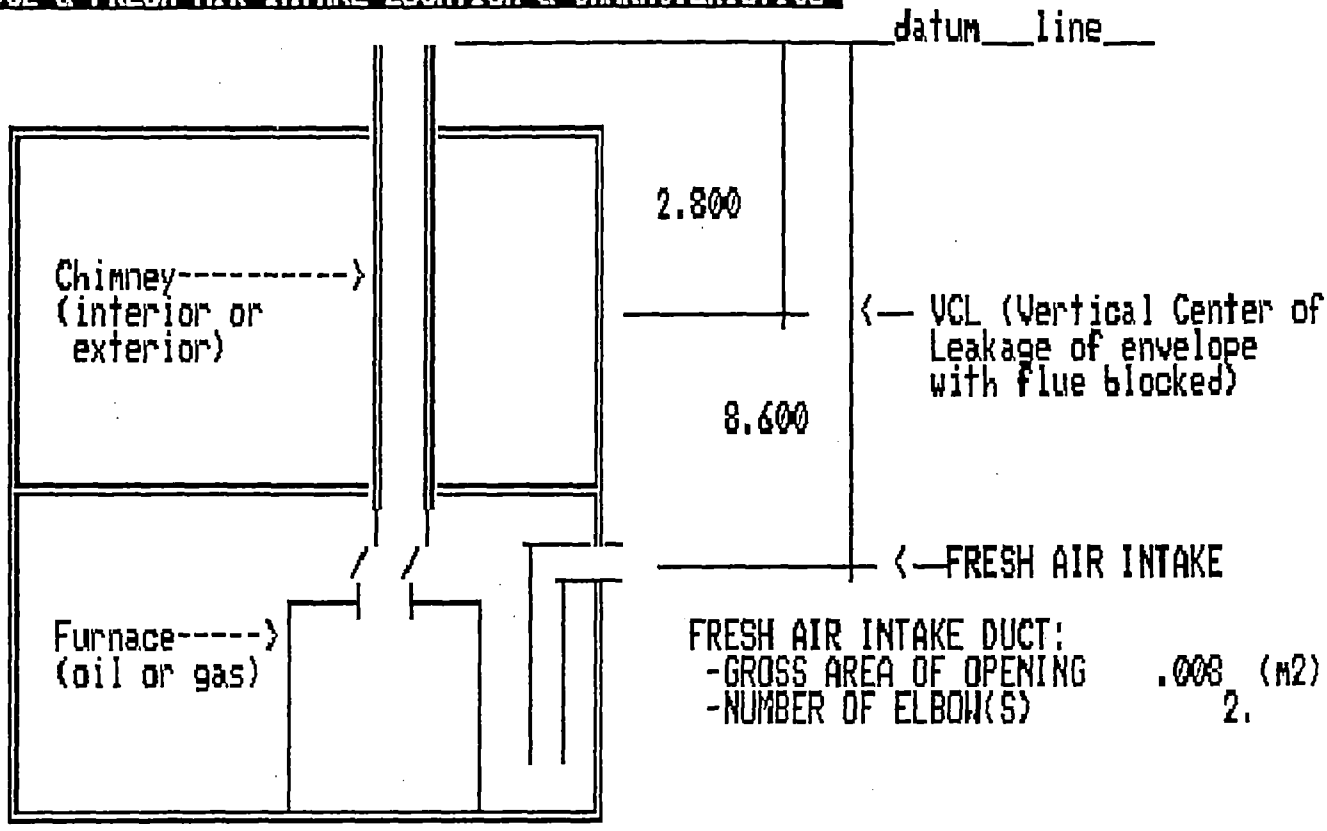
AMBIENT TEMPERATURE AND WIND SPEED

Outdoor Temperature	10.0 (C)	Wind Speeds:	-horizontal	0.0	(m/s)
Indoor Temperature	20.0 (C)		-vertical (up is +)	0.0	(m/s)

INITIAL TEMPERATURES OF ELEMENTS

Initial Flue Temperatures:	-flue gas	23.6	(C)
	-nodal point #1	23.3	(C)
	-nodal point #2	23.1	(C)
	-nodal point #3	20.2	(C)
Initial furnace temperatures:	-heat exchanger surface	25.8	(C)
	-stack gas	26.9	(C)

VCL & FRESH AIR INTAKE LOCATION & CHARACTERISTICS



FRESH AIR INTAKE DUCT:

-GROSS AREA OF OPENING	.008	(m2)
-NUMBER OF ELBOW(S)	2.	

DISTRIBUTION OF ENVELOPE LEAKS RELATIVE TO THE WIND DIRECTION

ENTER THE SELECTION WHICH BEST DESCRIBES THE ORIENTATION OF ENVELOPE LEAKS

(1. MAINLY WINDWARD 2. MAINLY LEEWARD 3. PARALLEL 4. UNIFORM 5. SHELTERED)

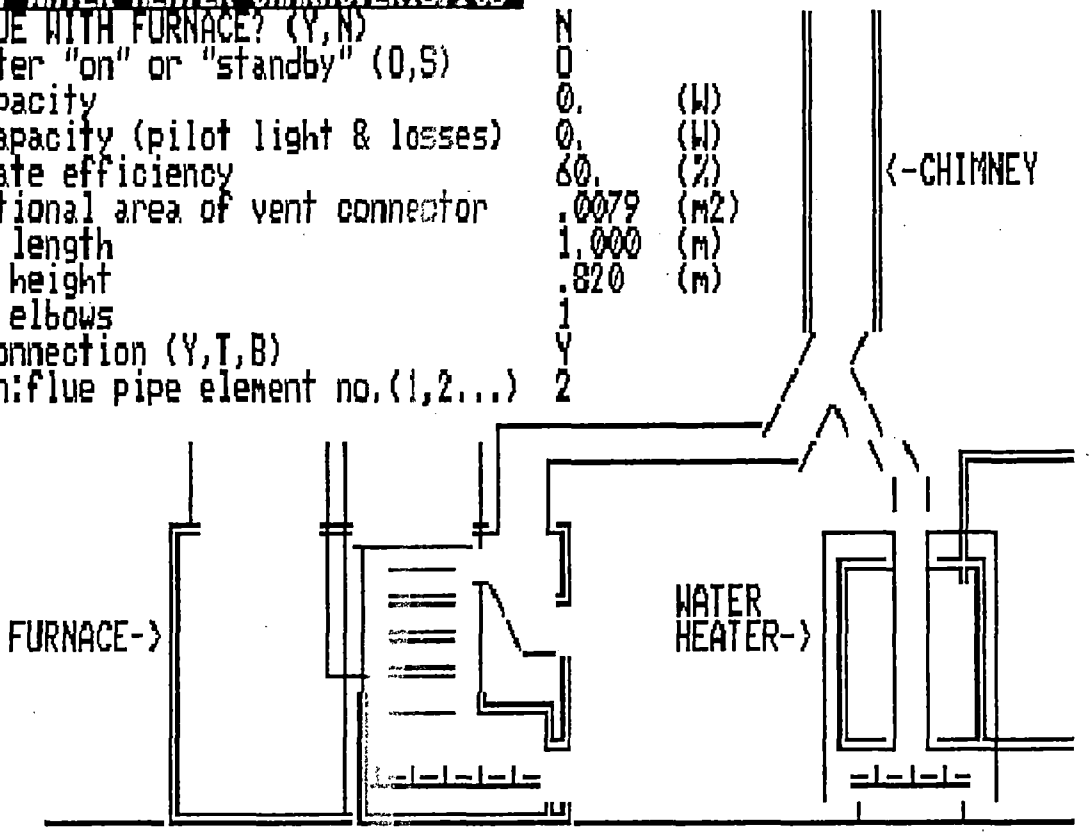
DEFAULT VALUE IS 5

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

DOMESTIC HOT WATER HEATER CHARACTERISTICS

-SHARED FLUE WITH FURNACE? (Y,N)	N	
-water heater "on" or "standby" (O,S)	O	
-burner capacity	0.	(W)
-standby capacity (pilot light & losses)	0.	(W)
-steady state efficiency	60.	(%)
-cross-sectional area of vent connector	.0079	(m2)
-flue pipe length	1.000	(m)
-flue pipe height	.820	(m)
-number of elbows	1	
-type of connection (Y,T,B)	Y	
-connection:flue pipe element no.(1,2...)	2	



FLUE DAMPER AND FLUE CAP

FLUE DAMPER:

-Is there a flue damper? (Y,N)	Y	
-Damper activation: thermal or electric? (T,E)	T	
-Thermal activation temperature: -fully open	188.	(°C)
-fully closed	35.	(°C)
-Leakage area around flue damper when closed	.00123	(m2)

FLUE CAP:

-Horizontal wind pressure coefficient (horizontal wind pressure coefficient is needed even if 'Actual wind angle' below is not 0°)	1.100	
-Actual wind angle (measured from horizontal: + up, - down)	0.0	(°)
-Wind pressure coefficient at that angle	1.100	
-Wind speed at that angle	0.000	(m/s)
-Flue gas friction factor	.70	

OPTIONAL SPECIFICATIONS

Furnace Thermostat Setting:

-thermostat setpoint	20.0 (°C)
-furnace thermostat band*	0.0 (°C)

House Thermal Characteristics:

-heated house volume	400.0 (m3)
-thermal conductivity of the house envelope	200.0 (W/°C)
-thermal mass of the house structure (L,M,or H)**	L

Mechanical Draft Inducer:

-Do you wish to include a draft inducer in the vent connector? (Y/N) N

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* -enter "0" if you want to specify the furnace ON & OFF times in TIME CONTROLS
-enter the number of degrees for the thermostat band to simulate the dynamic performance of the envelope/furnace/thermostat system, e.g."4.0"(C)

** enter "L" for ordinary wood frame structure, "M" for a wood frame house with interior mass e.g. brick, & "H" for a conc. block or solid masonry structure

TIME CONTROLS

Simulation Start Time	0.00	(sec)
Initial Time Step	1.00	(sec)
Furnace On	64.00	(sec)
Furnace Off	344.00	(sec)
Simulation Stop Time	3200.00	(sec)

APPENDIX H

FULL SHELTAIR TEST DATA

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

Sheltair Scientific Ltd. Field Test Data April 1-2,1987

Taken from Phil Porter's house on W. 13th Ave., Vancouver

Legend:

t1: Post-mixing flue wall temperature, C
t2: Post-mixing flue gas temp, C
t3: Breech gas temp, C
t4: Reference temp, C
t5: Temp. of flue gas 10 cm beyond b. damper, 1 cm below top side of flue, C
t6: Flue gas temp 10 cm beyond b. damper, center of stream, C
t7: Flue wall temp 10 cm beyond b. damper, C
t8: Flue gas temp at thimble, C
t9: Flue wall temp at thimble, C (found not well fixed to wall after test)
t10: First dilution air temp, C *
t11: \
t12: Volumetric chimney flow, l/s (corrected for temperature variation)
t13: Chimney top wall temp, C
t14: Second dilution air temp, C *
t15: Chimney top gas temp, C
p16: Chimney thimble static pressure, Pa

* see attached notes for explanation

Configuration: No barometric damper, hollow sleeve inserted
House Pressure: normal; Outdoor Temperature: 10 C

Time (s)	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t12	t13	t14	t15	p16	Comments	flow press.
0	19.46	24.74	38.40	16.81	26.05	26.71	23.26	18.63	22.11	16.20	9.12	22.90	16.14	19.60	1.5		3.3
14	19.46	24.41	38.56	16.81	26.05	26.71	23.26	18.47	21.78	16.20	9.12	22.90	16.14	19.60			3.3
25	19.30	24.74	38.72	16.81	26.05	26.87	23.26	18.63	21.78	16.20	9.13	22.90	16.14	19.60			3.3
36	19.30	25.07	38.24	16.81	26.05	26.71	23.26	18.13	21.78	16.20	8.60	22.80	16.31	19.60			3.2
48	19.30	25.07	38.24	16.81	26.05	26.87	23.26	18.47	22.11	16.20	9.13	22.80	16.81	19.60			3.3

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

59	19.30	24.90	38.72	16.81	26.22	27.04	23.26	18.47	22.11	16.70	13.27	22.80	18.96	19.70		Burner on at 64s. No spillage.	4.[illegible]
73	46.40	106.51	168.01	16.81	111.49	103.71	34.85	35.17	39.84	21.30	20.74	23.00	18.47	23.50			6.1
84	79.48	134.60	209.24	16.81	138.16	130.02	46.40	41.29	54.30	21.40	22.31	23.80	17.80	27.30	4.5		6.4
95	102.68	146.96	227.71	16.81	149.22	142.99	57.60	44.96	64.14	21.20	23.50	24.40	17.80	30.20			6.7
107	118.33	153.16	235.16	16.81	156.96	151.61	68.31	46.71	70.16	21.20	24.55	24.90	17.47	32.70			7
118	129.44	157.24	245.41	16.81	164.26	159.64	78.89	48.96	75.08	21.20	25.32	25.20	17.49	34.90	6.5		7.2
132	139.17	163.56	255.99	16.83	172.48	167.33	88.41	50.22	78.28	21.20	25.81	25.60	17.49	36.70			7.3
143	147.68	169.84	260.73	16.83	178.60	173.32	98.41	51.96	82.53	21.30	25.98	25.90	17.66	38.00			7.3
155	154.02	174.01	268.29	16.83	183.45	178.04	107.11	53.54	86.15	21.40	26.65	26.30	17.66	39.40	7		7.5
166	160.34	178.32	273.07	16.83	187.46	182.06	116.03	57.62	89.91	21.40	27.03	26.60	17.82	40.50			7.6
178	165.23	182.06	278.71	16.83	191.33	186.27	123.61	56.42	93.10	21.60	27.67	26.80	17.88	41.30	7.5		7.8
191	168.91	185.30	282.16	16.89	195.11	190.14	128.22	57.36	96.08	21.60	27.53	27.00	18.05	42.30			7.7
202	172.81	188.20	287.70	16.89	198.28	192.90	132.66	56.26	97.87	21.70	27.87	27.30	18.21	43.20		Fan turns on at 198s.	7.8
214	176.42	190.83	291.99	16.89	201.59	196.49	136.38	59.39	98.31	21.70	28.49	27.50	18.55	43.90	8		8
225	180.17	194.69	299.59	16.89	203.25	198.28	139.51	59.86	100.53	21.80	28.54	27.80	18.21	44.50			8
237	182.53	194.83	293.56	16.89	205.73	199.39	142.51	59.88	104.10	21.80	29.08	27.90	18.23	45.10	8.5		8.2
250	184.90	196.78	297.31	16.91	208.09	202.02	145.06	62.21	105.13	21.90	28.65	28.10	18.73	45.70			8
261	187.39	200.92	306.25	16.91	210.01	204.23	147.18	62.52	105.72	22.00	29.23	28.40	18.73	46.20			8.2
273	189.60	201.06	307.12	16.91	211.80	205.88	149.44	62.21	107.04	22.20	29.28	28.60	18.90	46.70	9		8.2
284	191.67	202.02	306.40	16.91	213.04	207.67	150.99	61.44	108.95	22.40	29.59	28.80	19.06	47.10			8.3
296	192.92	202.71	313.38	16.91	214.28	208.77	152.68	61.82	110.48	22.70	29.62	28.90	19.64	47.60	9		8.3
310	195.74	203.33	312.58	16.99	215.87	210.77	154.44	63.38	111.36	22.90	29.68	29.00	19.64	48.00			8.3
321	196.71	204.98	314.47	16.99	216.97	212.42	155.57	65.55	111.65	23.10	29.98	29.20	19.64	48.40			8.399999
333	198.23	207.19	320.05	16.99	218.48	212.84	156.69	63.22	112.82	23.40	30.00	29.40	19.64	48.80	9.2		8.399999
344	200.57	207.19	320.05	16.99	219.59	214.21	157.53	65.08	114.57	23.50	29.79	29.50	19.14	49.00	9.2		8.3
363	188.18	160.37	244.34	17.03	163.59	164.15	146.44	52.62	104.20	24.00	24.37	29.20	19.02	46.60		Burner turned off at 363s.	6.8
378	164.84	136.93	195.09	17.03	139.20	141.76	134.64	49.46	92.63	24.40	23.19	28.60	18.85	44.00			6.6
389	147.99	125.75	179.18	17.03	128.92	130.92	125.46	47.08	86.34	24.50	22.33	28.30	18.35	42.30	7.5		6.4
401	134.79	116.35	167.22	17.03	121.28	122.87	117.66	44.86	82.26	24.60	21.55	27.90	18.19	40.70			6.2
412	124.60	112.56	158.27	17.03	114.60	116.06	110.52	42.30	78.62	24.70	20.79	27.80	18.02	39.50			6
423	114.83	106.20	148.21	17.12	107.66	109.13	103.25	45.26	74.13	24.90	20.32	27.40	18.11	38.20	6.5		5.9
438	107.22	100.15	140.42	17.12	101.63	102.96	97.03	41.27	70.91	24.90	19.86	27.20	18.44	36.90			5.8
449	101.04	95.10	135.43	17.12	96.14	97.63	91.82	39.66	67.52	24.90	18.83	27.00	18.78	36.10	6		5.5
460	95.25	90.17	128.56	17.12	91.07	92.56	86.87	37.09	65.05	25.00	18.40	26.80	18.78	35.10			5.4
472	90.02	84.76	122.66	17.12	86.12	87.77	82.34	36.44	62.57	25.00	17.66	26.70	18.94	34.30			5.2

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

483	85.21	81.22	116.37	17.22	81.37	82.89	78.03	34.60	59.86	25.00	17.54	26.60	18.88	33.40	5		5.2
497	79.86	77.58	110.24	17.22	76.97	78.64	73.91	33.95	57.51	25.00	16.80	26.30	19.04	32.70			5
508	75.59	73.91	104.96	17.22	72.69	74.53	70.39	32.49	55.16	25.00	16.38	26.20	19.21	31.90			4.9
519	71.92	70.54	100.09	17.22	69.62	71.31	67.46	31.52	53.59	25.00	16.30	26.10	18.88	31.30		Fan turns off at 520s.	4.9
531	68.54	66.69	97.12	17.22	67.61	69.31	64.83	32.01	51.86	24.70	15.92	25.90	18.38	30.80			4.8
542	66.07	66.53	95.23	17.26	66.11	67.65	62.39	30.25	50.63	24.60	15.55	25.80	18.42	30.20	4.5		4.7
556	63.63	65.33	92.69	17.26	65.02	66.26	60.67	30.25	49.37	24.50	15.52	25.70	18.42	29.90			4.7
567	61.61	61.61	91.20	17.26	62.08	63.47	58.49	28.62	48.57	24.60	17.05	25.70	18.25	29.50			5.2
578	59.43	58.33	89.40	17.26	59.27	61.14	56.61	29.11	47.30	24.60	15.06	25.60	17.92	29.00			4.6
590	57.71	59.43	87.90	17.26	60.21	61.76	55.51	29.11	46.35	24.40	15.08	25.50	17.59	28.60			4.6
601	56.61	60.67	87.30	17.26	60.38	61.63	54.28	28.64	45.89	24.00	15.07	25.50	17.44	28.40	4		4.6
615	55.53	57.41	86.41	17.28	59.76	60.85	53.33	28.32	45.41	23.90	14.71	25.30	17.28	28.30			4.5
626	54.75	57.41	85.36	17.28	58.66	60.07	52.39	28.64	44.62	23.80	16.03	25.30	17.28	28.00			4.9
637	53.33	54.75	83.55	17.28	56.00	57.26	51.28	27.34	43.82	23.50	15.96	25.30	17.11	27.80			4.9
649	52.07	52.23	82.34	17.28	54.28	55.85	50.18	26.68	42.86	23.40	15.93	25.20	17.11	27.50			4.9
660	50.65	50.33	81.43	17.28	53.17	54.80	48.97	26.58	42.12	23.30	14.23	25.10	16.84	27.20			4.4
674	49.60	53.07	79.97	17.34	54.65	55.28	48.49	27.39	41.64	23.10	14.24	25.10	17.17	27.00			4.4
685	49.13	53.39	78.75	17.34	54.65	55.75	47.86	26.58	41.48	23.10	13.89	25.10	17.34	26.90			4.3
696	48.81	52.44	78.30	17.34	54.18	55.12	47.38	26.58	41.48	23.00	13.87	25.00	17.34	26.80			4.3
708	48.49	52.13	77.23	17.34	54.02	54.80	47.06	26.25	40.84	22.70	14.23	25.00	17.34	26.70			4.4
726	47.70	52.13	75.40	17.34	52.44	53.07	46.11	25.76	40.04	22.30	14.19	25.00	16.84	26.40			4.4
740	46.74	48.97	74.33	17.34	50.87	52.29	45.47	25.59	39.23	22.20	13.81	24.90	16.84	26.30			4.3
751	45.95	49.92	73.87	17.34	50.87	52.13	45.15	25.26	39.39	22.00	13.44	24.90	16.84	26.20			4.2
762	45.47	49.44	72.80	17.34	50.71	51.65	44.68	26.25	39.39	21.90	13.05	24.70	16.84	26.10			4.1
774	45.31	48.81	72.19	17.34	50.55	51.34	44.36	24.77	39.23	21.90	13.05	24.70	17.17	25.90			4.1
785	44.68	47.72	70.67	17.36	49.94	50.57	43.74	25.78	38.93	21.80	13.03	24.70	17.19	25.80	3.5		4.1
799	44.54	46.92	70.21	17.36	49.46	50.25	43.42	25.28	38.77	21.70	13.02	24.70	16.86	25.80			4.1
810	43.90	47.72	69.59	17.36	48.67	49.62	42.94	25.45	38.29	21.60	13.01	24.60	17.19	25.70			4.1
821	43.58	47.08	68.67	17.36	48.51	49.14	42.62	25.61	37.64	21.40	13.00	24.60	17.19	25.60			4.1
833	42.94	47.08	67.90	17.36	47.88	48.67	42.14	25.45	37.32	21.40	12.60	24.60	17.52	25.50			4
844	42.78	45.65	67.59	17.36	47.40	48.03	41.66	24.63	37.00	21.30	12.19	24.60	17.52	25.50			3.9
857	42.14	45.01	66.97	17.36	47.08	47.88	41.18	24.46	37.00	21.20	12.19	24.50	17.36	25.30			3.9
868	41.82	45.17	65.89	17.36	46.45	47.24	41.02	24.46	36.51	21.10	12.58	24.50	17.19	25.20			4
879	41.18	45.17	64.96	17.36	45.97	46.76	40.70	24.13	36.51	20.90	12.17	24.50	17.19	25.10			3.9
891	40.70	44.54	64.19	17.36	45.49	46.29	40.22	23.80	35.87	20.70	12.16	24.50	17.19	25.10			3.9

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

902	40.22	44.54	63.57	17.36	45.17	45.65	39.89	23.64	35.55	20.60	12.15	24.50	16.86	25.00		3.9
916	39.73	42.94	62.63	17.36	44.54	45.17	39.41	23.80	35.22	20.30	12.14	24.40	16.86	25.00		3.9
927	39.09	42.78	62.48	17.36	44.22	44.69	39.09	23.97	35.22	20.20	12.13	24.40	16.86	24.90		3.9
938	38.77	42.14	61.86	17.36	43.74	44.38	38.93	23.64	34.90	20.10	12.12	24.40	16.69	24.70		3.9
950	38.29	42.78	61.08	17.36	43.42	43.90	38.45	23.64	34.74	20.10	12.11	24.40	16.69	24.70		3.9
961	37.96	42.14	60.46	17.36	42.94	43.74	38.13	23.64	34.74	20.00	12.11	24.20	16.69	24.60		3.9
974	37.48	41.66	60.14	17.36	42.62	43.58	37.96	23.48	34.57	19.80	12.11	24.20	16.69	24.50		3.9
985	37.16	41.50	60.14	17.36	42.14	42.94	37.48	23.15	34.41	19.70	12.09	24.20	16.69	24.50		3.9
996	37.00	41.18	59.99	17.36	41.98	42.62	37.32	23.48	34.09	19.60	11.25	24.20	16.69	24.40		3.7
1008	36.51	40.38	59.05	17.36	41.66	42.14	37.00	22.98	33.93	19.60	12.08	24.20	16.69	24.40		3.9
1019	36.35	41.66	59.05	17.36	41.50	41.98	36.68	22.98	33.60	19.50	12.08	24.20	16.69	24.20		3.9
1032	35.87	40.70	58.11	17.36	41.02	41.66	36.51	22.65	33.44	19.50	11.66	24.10	16.69	24.20		3.8
1043	35.55	39.89	57.65	17.36	40.70	41.18	36.19	22.65	33.12	19.40	12.06	24.10	16.69	24.10		3.9
1054	35.22	39.89	56.86	17.36	40.22	40.86	35.87	22.98	33.12	19.20	11.22	24.10	16.69	24.10		3.7
1066	34.74	39.09	56.55	17.36	39.89	40.70	35.71	22.32	32.95	19.20	12.05	24.10	16.69	24.00		3.9
1084	34.09	38.77	55.90	17.34	39.39	40.04	35.36	22.14	32.77	19.10	12.04	24.10	16.67	23.90		3.9
1097	33.75	38.43	55.59	17.34	39.07	39.71	34.88	22.14	32.29	19.10	11.20	24.00	16.67	23.90		3.7
1108	33.58	38.75	54.96	17.34	38.91	39.39	34.72	21.97	32.29	19.00	11.20	24.00	16.67	23.80		3.7
1119	33.42	38.91	54.80	17.34	39.07	39.39	34.56	22.63	32.29	19.00	11.20	24.00	16.67	23.80		3.7
1131	33.10	38.11	54.33	17.34	38.75	39.07	34.39	21.97	32.29	18.90	11.19	24.00	16.67	23.80		3.7
1142	32.93	37.30	54.18	17.34	38.11	38.77	34.09	21.83	31.98	18.90	11.18	24.00	16.69	23.60		3.7
1156	32.63	36.35	53.88	17.36	37.96	38.45	33.93	21.33	31.65	18.90	11.18	24.00	16.69	23.60		3.7
1167	32.30	37.00	53.72	17.36	37.64	38.29	33.76	21.33	31.65	18.70	11.18	24.00	16.52	23.50		3.7
1178	32.14	36.19	53.41	17.36	37.32	38.13	33.60	21.83	31.33	18.70	10.74	23.90	16.52	23.50		3.6
1190	31.98	36.35	53.09	17.36	37.32	37.96	33.44	21.83	31.33	18.60	11.17	23.90	16.52	23.50		3.7
1201	31.98	35.22	52.46	17.36	36.68	37.48	32.95	21.83	31.33	18.60	10.72	23.90	16.52	23.40	2.5	3.6
1214	31.65	35.55	52.15	17.36	36.35	37.16	32.79	21.66	31.17	18.50	10.72	23.90	16.69	23.40		3.6
1225	31.17	34.57	51.99	17.36	36.19	37.16	32.79	21.83	31.17	18.50	10.72	23.90	16.69	23.30		3.6
1236	31.00	33.60	51.99	17.36	36.19	36.68	32.63	21.33	31.17	18.50	10.71	23.90	16.86	23.30		3.6
1248	31.00	32.63	51.36	17.36	35.71	36.51	32.30	21.66	30.84	18.50	11.14	23.80	16.86	23.10		3.7
1259	30.84	31.82	51.20	17.36	35.38	36.19	32.14	21.17	30.52	18.50	11.14	23.80	17.17	23.10		3.7
1272	30.50	31.96	50.87	17.34	35.20	36.17	31.96	21.15	30.50	18.50	11.14	23.80	16.84	23.10		3.7
1283	30.33	32.12	50.71	17.34	34.88	35.85	31.80	21.15	30.33	18.50	11.13	23.80	17.17	23.00		3.7
1294	30.17	30.98	49.92	17.34	34.72	35.53	31.64	20.98	30.33	18.50	11.13	23.80	17.34	23.00		3.7
1306	30.01	32.12	49.76	17.34	34.56	35.36	31.31	21.15	30.17	18.50	10.69	23.60	17.17	23.00		3.6

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

1317	29.84	31.80	49.60	17.34	34.39	34.88	31.15	21.15	29.84	18.50	11.11	23.80	16.86	22.90	3.7
1330	29.37	32.79	49.14	17.36	34.09	34.74	31.00	21.17	29.86	18.50	10.68	23.60	16.86	22.90	3.6
1341	29.21	32.63	49.14	17.36	34.09	34.74	31.00	21.00	29.86	18.50	10.68	23.60	16.69	22.80	3.6
1352	29.05	32.95	49.14	17.36	34.09	34.74	30.84	21.00	29.54	18.40	10.68	23.60	16.69	22.80	3.6
1364	28.72	31.65	48.67	17.36	33.76	34.57	30.52	20.84	29.54	18.30	10.67	23.60	16.69	22.80	3.6
1375	28.56	31.00	48.67	17.36	33.44	34.41	30.52	21.00	29.54	18.30	10.22	23.60	16.52	22.80	3.5
1387	28.25	31.19	48.53	17.38	33.14	34.11	30.37	21.02	29.39	18.30	10.67	23.60	16.71	22.70	3.6
1401	28.09	31.35	48.21	17.38	32.97	33.95	30.21	20.53	29.39	18.10	10.66	23.50	16.54	22.70	3.6
1412	27.76	31.84	47.74	17.38	32.97	33.78	30.21	20.36	29.23	18.10	10.21	23.50	16.54	22.70	3.5
1423	27.76	31.84	47.74	17.38	32.97	33.78	30.05	20.36	29.23	18.10	10.21	23.50	16.54	22.50	3.5
1442	27.43	31.35	47.74	17.38	32.81	33.62	29.88	20.86	28.74	18.10	9.73	23.50	16.71	22.50	3.4
1455	27.43	30.54	47.89	17.38	32.81	33.46	29.56	20.36	28.74	18.00	9.73	23.50	16.71	22.50	3.4
1466	27.27	30.21	47.26	17.38	32.65	33.46	29.39	20.53	28.74	18.10	10.20	23.50	16.71	22.50	3.5
1477	27.27	30.05	47.10	17.38	32.65	33.14	29.39	20.53	28.74	18.10	9.72	23.50	16.71	22.40	3.4
1489	27.27	30.05	46.94	17.38	32.65	33.14	29.39	20.36	28.74	18.10	9.72	23.50	16.71	22.40	3.4
1500	26.94	30.05	46.78	17.38	32.32	32.97	29.23	20.53	28.58	18.00	9.72	23.40	16.69	22.40	3.4
1514	26.92	29.86	46.45	17.36	32.14	32.95	29.21	20.34	28.40	18.00	10.19	23.40	16.69	22.40	3.5
1525	26.76	29.54	46.13	17.36	32.14	32.79	29.05	20.51	28.40	17.90	9.72	23.40	16.69	22.30	3.4
1536	26.60	30.19	45.65	17.36	32.14	32.63	29.05	20.17	28.40	17.90	9.71	23.40	16.52	22.30	3.4
1548	26.60	30.19	45.49	17.36	31.98	32.63	29.05	20.34	28.23	17.90	9.71	23.40	16.52	22.30	3.4
1559	26.43	30.03	45.97	17.36	31.82	32.30	28.72	20.34	28.23	17.80	9.71	23.40	16.50	22.30	3.4
1572	26.25	30.17	45.63	17.34	31.80	32.29	28.70	19.99	28.21	17.80	9.71	23.40	16.50	22.30	3.4
1583	26.25	30.01	45.47	17.34	31.80	32.12	28.54	19.99	28.05	17.80	9.70	23.40	16.50	22.20	3.4
1594	25.92	29.52	45.31	17.34	31.64	31.96	28.38	20.16	28.05	17.80	9.70	23.30	16.50	22.20	3.4
1606	25.92	29.52	45.31	17.34	31.15	31.80	28.38	19.82	28.05	17.60	9.70	23.30	16.50	22.20	3.4
1617	25.76	29.52	45.31	17.34	31.15	31.80	28.38	20.16	27.72	17.60	9.70	23.30	16.50	22.20	3.4
1629	25.59	29.36	45.15	17.34	30.98	31.64	28.21	19.99	27.72	17.60	9.70	23.30	16.50	22.00	3.4
1643	25.59	29.36	44.52	17.34	30.98	31.31	28.05	20.16	27.72	17.60	9.69	23.30	16.50	22.00	3.4
1654	25.43	29.19	44.52	17.34	30.82	31.15	28.05	19.82	27.56	17.50	9.69	23.30	16.50	22.00	3.4
1665	25.26	29.03	44.36	17.34	30.50	31.15	27.72	20.16	27.39	17.50	9.69	23.30	16.50	22.00	3.4
1677	25.26	29.19	44.36	17.34	30.50	31.15	27.56	19.99	27.23	17.50	9.69	23.30	16.50	21.90	3.4
1688	24.94	29.34	44.18	17.32	30.31	30.96	27.54	19.97	26.88	17.50	9.69	23.10	16.48	21.90	3.4
1702	24.92	29.34	44.50	17.32	30.31	31.13	27.54	19.80	26.88	17.50	9.69	23.10	16.48	21.90	3.4
1713	24.75	28.36	44.18	17.32	30.31	30.96	27.54	19.97	26.88	17.50	9.69	23.10	16.48	21.90	3.4
1724	24.75	29.01	44.18	17.32	30.31	30.96	27.37	19.97	26.88	17.50	9.69	23.10	16.48	21.90	3.4

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

1736	24.59	29.50	44.34	17.32	30.31	30.96	27.37	19.97	26.88	17.40	9.69	23.10	16.48	21.90	3.4
1747	24.59	28.36	44.30	17.28	30.27	30.93	27.34	19.76	26.84	17.40	9.69	23.10	16.44	21.90	3.4
1760	24.55	28.48	43.82	17.28	30.11	30.93	27.34	19.43	26.84	17.40	9.69	23.10	16.44	21.90	3.4
1771	24.38	28.15	43.66	17.28	30.11	30.76	27.34	19.43	26.84	17.40	9.68	23.10	16.44	21.80	3.4
1782	24.38	28.15	43.34	17.28	29.95	30.44	27.17	19.43	26.68	17.30	9.68	23.00	16.44	21.80	3.4
1801	24.05	28.15	42.70	17.28	29.95	30.27	27.17	19.76	26.68	17.30	9.68	23.00	16.42	21.80	3.4
1814	24.03	27.97	42.68	17.26	29.77	30.25	27.15	19.91	26.50	17.30	9.67	23.00	16.42	21.80	3.4
1825	23.87	27.97	42.84	17.26	29.44	30.09	26.82	19.41	26.50	17.30	9.67	23.00	16.42	21.70	3.4
1836	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26.82	19.25	26.50	17.30	9.67	23.00	16.42	21.70	3.4
1848	23.71	27.64	42.84	17.26	[illegible]	[illegible]	[illegible]	[illegible]	26.50	17.30	9.67	23.00	16.42	21.70	3.4
1859	23.71	27.48	42.52	17.26	29.44	29.93	26.66	19.41	26.33	[illegible]	[illegible]	[illegible]	[illegible]	21.70	3.4
1871	23.52	27.46	42.50	17.24	29.26	29.75	26.64	19.39	26.31	17.20	9.67	[illegible]	[illegible]	[illegible]	3.4
1885	23.52	26.64	42.50	17.24	29.09	29.75	26.64	19.39	26.31	17.20	9.67	23.00	16.57	21.60	3.4
1896	23.52	27.46	42.34	17.24	29.09	29.42	26.48	18.90	26.15	17.20	9.66	23.00	16.40	21.60	3.4
1907	23.36	27.13	41.86	17.24	29.09	29.42	26.48	19.23	26.15	17.20	9.66	22.90	16.57	21.60	3.4
1919	23.36	26.64	42.50	17.24	29.09	29.42	26.48	18.90	26.15	17.20	9.66	22.90	16.40	21.60	3.4
1930	23.03	27.26	42.62	17.20	28.89	29.71	26.44	19.35	25.78	17.20	9.67	22.90	16.36	21.60	3.4
1944	22.99	27.58	42.46	17.20	29.05	29.71	26.44	19.19	26.11	17.20	9.67	22.90	16.53	21.60	3.4
1955	22.99	27.42	42.62	17.20	29.05	29.71	26.44	19.19	26.11	17.00	9.67	22.90	16.36	21.60	3.4
1966	22.99	27.26	42.46	17.20	29.22	29.71	26.44	19.19	26.11	17.00	9.67	22.90	16.36	21.60	3.4
1978	22.99	27.26	41.98	17.20	29.05	29.38	26.44	19.19	26.11	17.00	9.66	22.90	16.36	21.60	3.4
1989	22.99	27.42	41.98	17.20	28.89	29.22	26.27	19.02	25.78	17.00	9.66	22.90	16.36	21.40	3.4
2003	22.82	27.26	41.98	17.20	28.89	29.22	26.27	19.19	25.78	17.00	9.66	22.90	16.36	21.40	3.4
2014	22.82	26.44	41.82	17.20	28.56	29.22	26.27	19.02	25.78	17.00	9.66	22.80	16.53	21.40	3.4
2025	22.82	27.09	41.50	17.20	28.56	29.22	26.11	19.02	25.78	17.00	9.16	22.80	16.53	21.40	3.3
2037	22.66	27.58	41.50	17.20	28.56	29.22	26.11	19.02	25.78	17.00	9.66	22.80	16.53	21.40	3.4
2048	22.66	27.42	41.66	17.20	28.53	29.18	26.07	18.82	25.74	16.90	9.16	22.80	16.49	21.40	3.3
2062	22.62	27.05	41.63	17.16	28.36	29.18	26.07	19.31	25.74	16.90	9.66	22.80	16.32	21.40	3.4
2073	22.62	26.73	41.63	17.16	28.36	29.02	26.07	19.15	25.58	16.90	9.66	22.80	16.32	21.40	3.4
2084	22.62	26.56	41.47	17.16	28.36	29.02	26.07	19.15	25.58	16.90	9.66	22.80	16.32	21.30	3.4
2096	22.45	27.05	41.47	17.16	28.20	28.85	26.07	18.98	25.58	16.90	9.65	22.80	16.32	21.30	3.4
2107	22.45	26.40	41.47	17.16	28.04	28.85	25.74	18.82	25.58	16.90	9.65	22.70	16.32	21.30	3.4
2121	22.12	26.73	41.47	17.16	27.87	28.53	25.74	18.98	25.41	16.90	9.65	22.80	16.32	21.30	3.4
2132	22.12	26.40	41.63	17.16	27.87	28.36	25.74	18.82	25.41	16.90	9.64	22.70	16.49	21.30	3.4
2143	21.96	26.07	40.82	17.16	27.87	28.20	25.58	18.98	25.25	16.90	10.11	22.70	16.49	21.30	3.5

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

2162	21.96	26.56	40.82	17.16	27.38	28.04	25.41	18.82	25.09	16.90	10.11	22.70	16.45	21.20		3.5
2175	21.92	26.69	40.95	17.12	27.18	28.00	25.37	18.78	25.05	16.90	9.64	22.70	16.45	21.20		3.4
2186	21.75	26.19	41.27	17.12	27.51	28.16	25.37	18.94	25.05	16.90	9.64	22.70	16.45	21.20		3.4
2197	21.75	26.03	40.79	17.12	27.51	28.16	25.37	18.78	25.05	16.90	9.64	22.70	16.45	21.20		3.4
2209	21.75	25.70	40.14	17.12	27.51	28.16	25.37	18.44	24.72	16.90	9.64	22.70	16.45	21.20		3.4
2220	21.75	26.52	40.14	17.12	27.51	28.00	25.37	18.78	25.05	16.80	9.64	22.70	16.45	21.20		3.4
2232	21.61	26.54	40.16	17.14	27.36	28.02	25.39	18.80	24.74	16.80	10.11	22.70	16.47	21.20		3.5
2246	21.77	25.72	40.64	17.14	27.36	28.02	25.23	18.80	24.74	16.80	9.64	22.50	16.47	21.10		3.4
2257	21.61	25.72	40.64	17.14	27.20	27.85	25.23	18.30	24.74	16.90	9.64	22.50	16.47	21.10		3.4
2268	21.61	26.38	40.48	17.14	27.20	27.85	25.23	18.46	24.74	16.90	9.64	22.50	16.47	21.10		3.4
2280	21.61	25.56	40.64	17.14	27.20	28.02	25.23	18.80	24.74	16.90	9.64	22.50	16.47	21.10	1.75	3.4
2291	21.44	26.21	40.64	17.14	27.20	28.02	25.23	18.46	24.74	16.90	9.64	22.50	16.47	21.10		3.4
2305	21.44	25.39	40.81	17.14	27.36	28.02	25.23	18.46	24.74	16.90	9.64	22.50	16.30	21.10		3.4
2316	21.44	26.05	40.97	17.14	27.36	27.85	25.07	18.80	24.74	16.90	9.64	22.50	16.30	21.10		3.4
2327	21.44	25.23	40.48	17.14	27.36	27.85	25.07	18.96	24.74	16.90	9.64	22.50	16.47	21.10		3.4
2339	21.11	25.72	40.48	17.14	27.20	27.85	25.07	18.46	24.57	16.90	9.64	22.50	16.47	21.10		3.4
2350	21.11	25.07	40.48	17.14	27.20	27.85	25.07	18.80	24.57	16.90	9.64	22.50	16.30	21.10		3.4
2364	21.11	25.72	40.16	17.14	27.36	27.85	25.07	18.96	24.57	16.90	9.64	22.40	16.30	20.90		3.4
2375	20.95	25.56	40.00	17.14	27.36	27.85	25.07	18.80	24.57	16.90	9.64	22.40	16.30	20.90		3.4
2386	20.95	25.39	40.16	17.14	27.52	28.02	25.07	18.80	24.57	16.80	9.14	22.40	16.30	20.90		3.3
2398	20.95	25.07	40.16	17.14	27.36	28.18	25.07	18.80	24.57	16.80	9.64	22.40	16.30	20.90		3.4
2409	20.95	25.39	40.16	17.14	27.36	28.02	25.07	18.46	24.74	16.80	9.64	22.40	16.30	20.90		3.4
2423	20.95	25.39	40.16	17.14	27.20	27.85	25.07	18.46	24.74	16.80	9.64	22.40	16.30	20.90		3.4
2434	20.95	25.56	40.16	17.14	27.03	27.85	25.07	18.80	24.74	16.80	9.64	22.40	16.30	20.90		3.4
2445	20.95	25.39	40.16	17.14	27.20	27.52	25.07	18.30	24.57	16.80	9.63	22.40	16.30	20.90		3.4
2457	20.95	25.56	40.48	17.14	27.03	27.52	25.07	18.46	24.57	16.80	9.63	22.40	16.30	20.90		3.4
2468	20.95	25.23	40.16	17.14	27.03	27.51	24.72	18.78	24.55	16.80	9.63	22.40	16.28	20.90		3.4
2482	20.93	25.70	40.14	17.12	26.69	27.51	24.72	18.44	24.55	16.80	9.63	22.40	16.28	20.90		3.4
2493	20.93	25.05	39.82	17.12	27.01	27.34	24.72	18.94	24.39	16.70	9.63	22.30	16.28	20.90		3.4
2504	20.93	25.54	39.66	17.12	27.01	27.51	24.72	18.78	24.39	16.70	9.14	22.40	16.28	20.80		3.3
2523	20.93	25.54	39.50	17.12	27.18	27.83	24.72	18.78	24.39	16.70	9.64	22.30	16.28	20.80		3.4
2536	20.93	25.37	39.66	17.12	27.01	27.83	24.72	18.78	24.39	16.70	9.64	22.30	16.45	20.80		3.4
2547	20.93	26.19	39.66	17.12	27.01	27.51	24.72	18.78	24.39	16.70	9.14	22.30	16.45	20.80		3.3
2558	20.93	25.70	39.66	17.12	27.01	27.51	24.72	18.78	24.39	16.70	9.63	22.30	16.45	20.80		3.4
2570	20.93	26.03	39.50	17.12	26.69	27.51	24.72	18.44	24.39	16.70	9.63	22.30	16.45	20.80		3.4

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

2581	20.93	25.37	39.50	17.12	26.69	27.34	24.72	18.44	24.22	16.70	9.63	22.30	16.45	20.80	3.4
2593	20.93	25.70	39.66	17.12	26.69	27.34	24.72	18.78	24.22	16.70	9.63	22.30	16.45	20.80	3.4
2607	20.76	25.70	39.82	17.12	26.52	27.34	24.55	18.44	24.22	16.70	9.63	22.30	16.45	20.80	3.4
2618	20.76	25.37	39.66	17.12	26.52	27.18	24.55	18.78	24.22	16.70	9.63	22.20	16.45	20.80	3.4
2629	20.76	25.54	39.50	17.12	26.19	27.01	24.55	18.78	24.22	16.70	9.62	22.30	16.45	20.70	3.4
2641	20.76	25.05	39.18	17.12	26.36	26.69	24.39	18.44	23.90	16.70	10.09	22.20	16.45	20.70	3.5
2652	20.76	25.35	39.15	17.09	26.17	26.66	24.36	18.41	23.87	16.70	9.62	22.20	16.25	20.70	3.4
2666	20.57	25.51	39.47	17.09	26.33	26.98	24.36	18.41	23.70	16.70	9.62	22.20	16.25	20.70	3.4
2677	20.73	25.18	39.63	17.09	26.33	26.98	24.36	18.41	23.70	16.70	9.62	22.20	16.42	20.70	3.4
2688	20.73	25.18	39.47	17.09	26.17	26.98	24.36	18.25	23.87	16.70	9.62	22.20	16.25	20.70	3.4
2700	20.73	25.51	39.63	17.09	26.33	26.98	24.36	18.25	23.87	16.70	9.62	22.20	16.25	20.70	3.4
2711	20.73	25.51	39.43	17.05	26.29	26.95	24.32	18.71	23.83	16.70	9.62	22.20	16.21	20.70	3.4
2725	20.69	24.48	39.11	17.05	26.29	26.95	24.32	18.37	23.66	16.70	9.62	22.20	16.21	20.70	3.4
2736	20.69	25.31	38.95	17.05	26.13	26.95	24.32	18.21	23.66	16.70	9.62	22.20	16.21	20.70	3.4
2747	20.53	24.98	39.11	17.05	26.29	26.95	24.32	18.21	23.66	16.70	9.62	22.20	16.21	20.70	3.4
2759	20.53	25.31	38.95	17.05	26.13	26.62	24.16	18.37	23.66	16.70	9.62	22.00	16.21	20.60	3.4
2770	20.53	25.31	39.11	17.05	26.11	26.60	24.14	18.35	23.48	16.70	9.62	22.00	16.36	20.70	3.4
2784	20.51	25.45	38.93	17.03	26.11	26.60	24.14	18.02	23.48	16.70	9.62	22.00	16.36	20.60	3.4
2795	20.51	24.46	38.93	17.03	26.11	26.60	24.14	18.19	23.48	16.70	9.62	22.00	16.36	20.60	3.4
2806	20.18	24.46	38.77	17.03	26.43	26.93	24.14	18.19	23.64	16.70	9.62	22.00	16.36	20.60	3.4
2818	20.18	25.61	39.09	17.03	26.27	26.93	24.14	18.35	23.64	16.70	9.62	22.00	16.36	20.60	3.4
2829	20.18	25.29	39.41	17.03	26.27	26.58	24.12	18.33	23.46	16.70	9.62	22.00	16.17	20.60	3.4
2843	20.16	25.10	39.07	17.01	26.25	26.91	24.12	18.33	23.46	16.70	9.62	22.00	16.17	20.60	3.4
2854	20.16	25.27	39.40	17.01	26.09	26.91	24.28	18.17	23.46	16.60	9.13	22.00	16.17	20.60	3.3
2865	20.16	25.59	38.91	17.01	26.41	27.07	24.12	18.17	23.62	16.60	9.13	22.00	16.17	20.60	3.3
2884	20.16	24.94	38.91	17.01	26.41	27.07	24.28	18.67	23.62	16.60	9.13	22.00	16.17	20.60	3.3
2897	20.16	24.94	39.07	17.01	26.41	27.07	24.28	18.67	23.62	16.60	9.13	21.90	16.17	20.60	3.3
2908	20.16	24.61	39.40	17.01	26.41	27.07	24.28	18.33	23.62	16.60	9.13	21.90	16.17	20.60	3.3
2919	20.16	25.10	38.91	17.01	26.41	27.07	24.28	18.17	23.62	16.60	9.13	21.90	16.17	20.60	3.3
2931	20.16	25.59	39.07	17.01	26.41	27.07	24.28	18.17	23.62	16.60	9.13	21.90	16.17	20.60	3.3
2942	20.16	25.10	39.07	17.01	26.41	27.07	24.28	18.17	23.62	16.60	9.62	21.90	16.17	20.60	3.4
2954	20.14	24.59	39.38	16.99	26.23	26.89	24.26	18.65	23.60	16.60	9.13	21.90	16.15	20.60	3.3
2968	20.14	24.92	39.54	16.99	26.39	27.05	24.26	18.31	23.60	16.60	9.13	21.90	16.15	20.60	3.3
2979	20.14	25.41	39.38	16.99	26.23	26.89	24.26	18.15	23.44	16.60	9.13	21.90	16.15	20.60	3.3
2990	20.14	25.25	39.05	16.99	26.23	26.89	24.26	18.31	23.44	16.60	9.62	21.90	16.15	20.60	3.4

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

3002	20.14	25.41	39.05	16.99	26.23	26.89	24.10	18.31	23.44	16.60	9.62	21.90	16.32	20.60	3.4
3013	20.14	25.08	38.73	16.99	26.23	26.89	24.10	18.15	23.44	16.60	9.13	21.90	16.15	20.60	3.3
3027	20.14	25.08	38.73	16.99	26.23	26.89	24.10	18.31	23.44	16.40	9.13	21.90	16.32	20.60	3.3
3038	20.14	25.25	38.57	16.99	26.23	26.56	24.10	18.31	23.44	16.40	9.62	21.90	16.32	20.60	3.4
3049	20.14	25.41	38.89	16.99	26.07	26.89	24.10	18.15	23.44	16.60	9.13	21.80	16.15	20.50	3.3
3061	20.14	25.25	38.73	16.99	26.23	26.56	24.10	18.15	23.44	16.40	9.12	21.80	16.15	20.50	3.3
3072	19.97	24.92	38.87	16.97	26.21	26.54	24.08	18.63	23.42	16.40	9.62	21.80	16.13	20.50	3.4
3086	20.12	24.57	39.04	16.97	26.05	26.54	24.08	18.29	23.25	16.40	9.62	21.80	16.30	20.50	3.4
3097	19.95	24.41	39.04	16.97	26.05	26.54	24.08	18.13	23.09	16.60	9.62	21.80	16.30	20.50	3.4
3108	19.95	25.06	39.36	16.97	26.05	26.54	24.08	18.29	23.25	16.40	9.62	21.80	16.30	20.50	3.4
3120	19.95	25.23	38.87	16.97	26.05	26.54	24.08	18.13	23.25	16.60	9.62	21.80	16.30	20.50	3.4
3131	19.95	25.06	38.71	16.97	26.07	26.39	24.10	18.15	23.27	16.40	9.61	21.80	16.32	20.50	3.4
3145	19.97	25.08	38.73	16.99	26.07	26.39	24.10	18.15	23.27	16.40	9.61	21.80	16.32	20.50	3.4
3156	19.97	24.59	38.89	16.99	26.07	26.56	23.77	18.31	23.44	16.40	9.62	21.80	16.15	20.50	3.4
3167	19.97	24.59	39.38	16.99	26.07	26.56	24.10	18.31	23.27	16.40	9.62	21.80	16.32	20.50	3.4
3179	19.97	25.25	38.73	16.99	25.90	26.56	23.77	18.31	23.27	16.60	9.62	21.80	16.32	20.50	3.4
3190	19.97	25.08	38.57	16.99	26.07	26.37	23.75	18.29	23.25	16.40	9.61	21.70	16.30	20.50	3.4
3204	19.95	24.90	38.71	16.97	26.05	26.37	23.75	18.29	23.25	16.40	9.61	21.70	16.30	20.50	3.4
3215	19.95	24.41	38.55	16.97	26.05	26.54	23.75	18.13	23.25	16.40	9.62	21.70	16.30	20.50	3.4
3226	19.95	24.57	38.55	16.97	26.05	26.54	23.75	18.13	23.25	16.60	9.62	21.70	16.30	20.50	3.4
3245	19.95	24.57	38.87	16.97	26.05	26.37	23.75	18.29	23.25	16.60	9.61	21.70	16.32	20.30	3.4
3258	19.97	25.25	39.05	16.99	25.90	26.56	23.77	18.31	23.27	16.40	9.62	21.70	16.32	20.50	3.4
3269	19.97	25.25	38.89	16.99	26.07	26.56	23.77	17.98	23.27	16.40	9.62	21.70	16.32	20.30	3.4
3280	19.97	25.08	38.57	16.99	26.07	26.56	23.77	18.15	23.27	16.40	9.62	21.70	16.32	20.30	3.4
3292	19.97	24.59	38.41	16.99	25.90	26.39	23.77	18.31	23.11	16.40	9.61	21.70	16.32	20.30	3.4
3303	19.97	24.43	38.73	16.99	26.07	26.39	23.77	18.15	23.27	16.40	9.61	21.70	16.32	20.30	3.4
3315	19.95	24.57	38.71	16.97	26.05	26.37	23.75	18.13	23.25	16.40	9.61	21.70	16.30	20.30	3.4
3329	19.79	25.06	38.39	16.97	26.05	26.37	23.75	18.13	23.09	16.40	9.61	21.70	16.30	20.30	3.4
3340	19.79	24.57	38.55	16.97	26.05	26.37	23.75	18.29	23.25	16.40	9.61	21.70	16.30	20.30	3.4
3351	19.79	24.90	38.55	16.97	25.88	26.37	23.75	18.13	23.09	16.40	9.61	21.60	16.30	20.30	3.4
3363	19.79	24.24	38.87	16.97	25.88	26.37	23.75	18.13	23.09	16.60	9.61	21.70	16.30	20.30	3.4
3374	19.79	24.41	38.71	16.97	25.88	26.37	23.75	18.29	23.09	16.40	9.61	21.70	16.30	20.30	3.4
3388	19.79	24.57	38.55	16.97	25.55	26.37	23.75	18.13	23.09	16.40	9.61	21.60	16.30	20.30	3.4
3399	19.79	24.57	38.71	16.97	25.55	26.37	23.75	18.13	23.09	16.40	9.61	21.60	16.30	20.30	3.4
3410	19.79	25.06	38.71	16.97	25.55	26.37	23.75	18.13	23.09	16.40	9.61	21.60	16.30	20.30	3.4

DAMPER FIELD TEST NO. 1:HEAT-UP COOL-DOWN WITH NO DAMPER

3422	19.62	25.23	38.39	16.97	25.55	26.21	23.75	17.96	23.09	16.60	9.61	21.60	16.30	20.30	3.4
3433	19.79	25.23	38.67	16.93	25.52	26.34	23.71	17.92	23.05	16.40	9.12	21.60	16.26	20.30	3.3
3447	19.75	25.19	38.35	16.93	25.84	26.34	23.71	17.92	23.05	16.60	9.61	21.60	16.26	20.30	3.4
3458	19.75	24.53	38.51	16.93	25.84	26.34	23.71	17.92	22.72	16.60	9.61	21.60	16.26	20.30	3.4
3469	19.75	25.19	38.67	16.93	25.84	26.34	23.71	18.09	22.72	16.60	9.61	21.60	16.26	20.30	3.4
3481	19.75	25.19	38.84	16.93	25.84	26.34	23.71	18.25	22.72	16.60	9.12	21.60	16.26	20.30	3.3
3492	19.75	24.86	38.67	16.91	25.99	26.32	23.69	18.07	22.70	16.40	9.61	21.60	16.24	20.30	3.4
3506	19.73	25.00	38.66	16.91	25.82	26.32	23.69	17.90	22.70	16.40	9.61	21.60	16.24	20.30	3.4
3517	19.73	25.00	38.49	16.91	25.82	26.32	23.69	18.07	22.70	16.40	9.61	21.60	16.24	20.30	3.4
3528	19.73	24.51	38.33	16.91	25.82	26.32	23.69	18.23	22.70	16.40	9.61	21.60	16.24	20.30	3.4
3540	19.73	24.84	38.49	16.91	25.82	26.32	23.69	18.23	22.70	16.40	9.61	21.40	16.24	20.30	3.4
3551	19.73	24.84	38.82	16.91	25.82	26.32	23.69	18.23	23.03	16.40	9.12	21.40	16.24	20.30	3.3
3565	19.73	24.51	38.66	16.91	25.99	26.32	23.69	18.23	22.70	16.40	9.12	21.40	16.24	20.20	3.3
3576	19.73	24.51	38.66	16.91	25.99	26.48	23.69	18.23	22.70	16.40	9.61	21.40	16.24	20.20	3.4
3587	19.73	24.84	38.66	16.91	25.82	26.32	23.69	18.07	22.70	16.40	9.61	21.40	16.24	20.20	3.4
3606	19.56	24.84	38.82	16.91	25.82	26.32	23.69	18.23	22.70	16.40	9.61	21.40	16.22	20.20	3.4

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

Sheltair Scientific Ltd. Field Test Data April 1-2,1987

Taken from Phil Porter's house on W. 13th Ave., Vancouver

Legend:

t1: Post-mixing flue wall temperature, C
t2: Post-mixing flue gas temp, C
t3: Breech gas temp, C
t4: Reference temp, C
t5: Temp. of flue gas 10 cm beyond b. damper, 1 cm below top side of flue, C
t6: Flue gas temp 10 cm beyond b. damper, center of stream, C
t7: Flue wall temp 10 cm beyond b. damper, C
t8: Flue gas temp at thimble, C
t9: Flue wall temp at thimble, C
t10: First dilution air temp, C *
t11: \
t12: Volumetric chimney flow, l/s (corrected for temperature variation)
t13: Chimney top wall temp, C
t14: Second dilution air temp, C *
t15: Chimney top gas temp, C
p16: Static pressure at chimney thimble, Pa

* see attached notes for explanation

Configuration: Ameritherm damper in vent connector
House Pressure: normal; Outdoor Temperature: 8.4 to 10.8 C as test ran

Time (s)	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t12	t13	t14	t15	p16	Comments	flow press.
0	27.28	33.47	39.76	15.88	29.07	28.91	26.79	16.72	16.55	17.90	4.32	13.00	15.72	16.70	2		2.80
13	27.28	33.47	39.60	15.88	29.07	28.91	26.95	16.55	16.55	18.00	4.32	13.00	15.38	16.70			2.80
24	27.28	33.47	39.60	15.88	29.07	29.07	26.95	16.22	16.55	18.10	4.32	13.00	15.72	16.70			2.80
35	27.28	33.30	39.76	15.88	29.07	29.07	26.95	16.55	16.55	18.30	3.05	13.00	15.72	16.70			2.70
46	27.60	33.30	39.76	15.88	29.40	29.07	26.95	16.72	16.55	18.10	3.05	13.00	15.72	16.70			2.70

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

58	27.60	33.30	39.60	15.90	29.42	29.09	27.13	16.74	16.57	18.70	4.32	13.00	28.93	16.70	2	Burner on at 64s. Slight	2.80
71	30.24	94.02	158.16	15.90	49.50	49.98	41.22	19.89	16.57	42.70	6.31	13.00	57.69	16.70	2.5	spillage for 40s	3.00
82	46.33	142.22	205.47	15.90	84.11	88.33	63.92	31.21	18.07	61.30	10.02	13.10	63.30	18.10	3		3.50
93	69.02	164.04	223.38	15.90	112.75	120.45	98.18	43.14	30.40	71.50	14.37	13.60	47.60	20.90			4.30
105	90.58	174.08	233.31	15.90	133.11	142.22	119.29	46.33	45.54	69.80	17.54	14.50	35.59	23.90	4.5		5.00
116	107.33	178.94	240.64	15.90	148.03	156.62	135.25	45.69	60.50	65.40	18.57	15.60	27.95	26.40			5.20
130	121.61	182.96	246.74	15.90	161.39	167.11	147.61	48.08	73.93	58.50	20.52	16.30	23.52	28.80	6		5.70
141	131.25	187.94	262.89	15.90	171.16	175.19	158.30	47.60	83.51	52.80	21.37	17.00	20.88	30.70			5.90
152	139.53	190.43	272.01	15.90	178.24	181.29	168.09	46.65	90.73	48.30	21.83	17.50	19.56	32.40	7		6.00
164	146.90	193.60	273.28	15.90	184.76	186.00	174.77	48.24	95.95	44.50	22.27	18.00	18.73	34.00			6.10
175	153.25	197.19	276.80	15.90	189.74	190.29	171.75	50.33	99.85	41.20	23.31	18.50	18.44	35.50	7.5		6.40
189	159.32	199.71	287.90	15.94	194.88	194.33	182.58	53.33	102.51	38.90	24.02	18.70	18.11	36.80			6.60
200	163.38	201.78	291.03	15.94	199.02	197.92	188.66	55.38	105.01	36.90	24.41	19.10	18.11	37.80		Fan turns on.	6.70
211	167.29	201.09	293.32	15.94	202.05	200.81	191.98	55.69	107.07	35.60	25.08	19.50	18.11	38.80			6.90
223	171.05	205.50	292.18	15.94	205.50	203.29	187.42	55.69	107.95	34.40	25.43	19.70	18.11	39.50			7.00
234	174.11	206.33	297.77	15.94	208.39	205.36	191.70	58.27	109.63	33.20	25.49	20.10	18.52	40.60	8.3		7.00
249	177.23	207.22	304.18	16.02	211.21	207.91	193.70	59.68	111.39	32.20	26.41	20.30	18.52	41.30			7.30
260	179.45	210.11	311.00	16.02	213.28	210.25	192.19	58.27	112.27	31.60	26.48	20.60	18.68	41.90			7.30
272	181.67	213.28	311.15	16.02	214.93	212.04	187.21	60.77	113.29	31.10	26.53	20.70	18.85	42.70	9		7.30
283	183.75	210.94	314.51	16.02	217.27	213.83	182.78	60.92	114.60	30.70	27.14	20.90	18.85	43.20			7.50
294	185.69	213.28	317.44	16.02	218.65	215.35	185.13	60.65	116.38	30.50	26.90	21.20	19.06	43.60			7.40
308	188.07	216.62	320.26	16.06	220.34	217.03	190.42	62.21	117.11	30.10	27.50	21.30	19.22	44.30	9		7.60
319	189.45	217.17	323.06	16.06	221.58	218.55	195.81	63.14	117.98	30.00	27.27	21.60	19.72	44.70			7.50
331	191.25	218.13	326.61	16.06	223.23	220.48	197.88	60.65	118.85	29.90	27.87	21.70	19.88	45.20			7.70
342	193.32	219.24	328.25	16.06	224.61	221.86	197.33	65.15	118.85	29.70	27.91	21.80	19.55	45.50	9.2		7.70
361	192.14	187.30	256.38	16.14	187.99	181.90	173.71	54.61	112.36	29.70	21.53	21.60	18.96	43.80	9.5	Burner off at 201 s	5.90
375	173.85	159.48	200.56	16.14	165.77	162.00	157.51	48.77	103.56	29.50	19.39	20.20	18.96	41.30	8		5.40
386	158.36	150.62	182.59	16.14	155.97	152.74	147.80	47.35	98.24	29.20	18.13	19.50	18.96	39.50	7.5		5.10
397	146.81	143.98	171.63	16.14	148.22	145.40	139.72	46.23	93.03	29.10	17.23	19.10	19.12	38.00			4.90
409	138.01	136.59	162.84	16.14	141.29	138.87	132.88	45.60	87.79	28.90	15.95	18.70	19.12	36.70	7.5		4.60
420	130.59	130.24	154.23	16.24	134.53	132.10	125.93	44.90	82.00	28.80	15.00	18.40	19.72	35.30	7		4.40
434	123.19	124.49	147.18	16.24	127.95	125.79	120.16	46.17	76.22	28.50	13.59	18.10	19.89	34.10			4.10
445	117.40	119.14	140.09	16.24	122.18	119.87	114.78	43.94	70.40	28.40	12.56	17.90	19.89	33.00			3.90
456	112.16	113.91	133.53	16.24	116.53	114.64	109.82	44.58	65.16	28.00	11.98	17.60	19.72	32.10			3.80
468	107.03	108.50	127.37	16.24	111.57	109.38	105.12	44.42	60.65	27.80	11.39	17.50	19.72	31.10			3.70

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

479	102.62	103.50	121.24	16.32	106.08	104.46	100.32	42.90	55.41	27.70	10.79	17.30	19.47	30.20	5.5		3.60
492	97.95	98.40	115.14	16.32	101.36	100.03	95.72	40.66	51.63	27.70	9.60	17.20	19.30	29.40			3.40
503	94.23	93.94	110.33	16.32	97.21	96.32	91.99	40.82	47.52	27.40	9.55	17.00	18.81	28.50		Fan turns off at 498s.	3.40
514	90.95	91.40	107.98	16.32	94.38	93.64	88.70	38.89	44.33	27.50	9.52	16.80	18.31	27.90	5		3.40
526	88.25	89.75	105.49	16.32	91.85	91.40	85.69	38.25	41.62	27.30	8.87	16.70	17.65	27.30			3.30
537	86.14	88.25	104.31	16.32	89.75	89.49	82.86	38.44	38.77	27.50	8.19	16.70	17.69	26.80			3.20
550	84.07	87.23	102.87	16.36	87.83	87.38	80.44	36.19	36.51	27.30	8.17	16.60	17.52	26.30			3.20
561	82.41	85.73	101.84	16.36	86.18	85.73	78.01	34.41	35.38	27.30	8.15	16.40	17.35	25.90			3.20
572	80.74	84.67	99.62	16.36	84.52	84.07	75.72	32.63	33.60	27.20	7.42	16.30	17.35	25.60	4.5		3.10
584	79.38	83.62	98.14	16.36	83.01	82.71	73.58	31.65	32.46	27.00	7.41	16.30	17.52	25.30			3.10
595	77.85	82.41	96.35	16.36	81.65	81.20	71.74	31.33	31.20	26.90	7.39	16.20	17.39	25.00			3.10
609	76.06	81.38	94.75	16.40	80.17	79.56	70.09	30.06	30.39	26.80	7.38	16.20	17.39	24.60			3.10
620	74.69	80.47	93.26	16.40	78.65	78.20	68.55	30.39	29.57	26.90	7.36	16.10	17.39	24.40			3.10
631	73.46	79.41	92.07	16.40	77.43	77.13	67.16	29.08	28.92	27.20	7.35	16.10	17.39	24.10			3.10
643	72.24	78.50	90.72	16.40	76.22	75.76	66.08	28.27	28.10	27.20	7.34	15.90	17.39	23.90			3.10
654	71.01	77.43	89.52	16.40	75.15	74.69	65.00	27.45	27.12	27.20	6.55	15.90	17.46	23.80			3.00
667	69.85	76.58	88.69	16.47	73.84	73.53	63.82	27.36	26.37	27.40	6.54	15.80	17.46	23.50			3.00
678	68.77	75.67	87.03	16.47	72.76	72.46	62.73	28.17	26.05	27.70	6.53	15.80	17.46	23.30			3.00
689	67.84	74.75	86.13	16.47	71.84	71.38	61.80	27.36	25.72	27.90	5.65	15.80	17.46	23.10	4		2.90
701	66.92	74.14	84.77	16.47	70.77	70.61	60.87	28.17	25.06	27.70	5.64	15.70	17.30	23.00			2.90
719	65.37	72.46	82.98	16.49	68.94	68.94	59.48	28.68	24.59	27.50	5.63	15.70	17.32	22.70	4		2.90
732	64.46	71.55	81.77	16.49	68.02	68.17	58.70	29.01	24.09	27.50	5.62	15.70	17.15	22.50			2.90
743	63.69	70.63	80.71	16.49	67.09	67.40	57.92	28.36	23.77	27.50	5.61	15.70	17.15	22.40			2.90
754	62.75	70.17	79.49	16.49	66.16	66.47	57.30	27.87	23.27	27.40	7.24	15.70	17.15	22.30			3.10
766	61.98	69.10	78.58	16.49	65.08	65.85	56.51	27.21	22.94	27.30	6.47	15.60	16.82	22.20			3.00
777	61.20	68.17	77.36	16.49	64.15	64.81	55.77	29.21	22.82	26.80	6.46	15.60	16.69	22.00			3.00
791	60.46	67.13	76.33	16.53	62.95	63.88	54.98	27.91	22.82	26.80	5.59	15.60	16.69	21.80			2.90
802	59.68	66.51	75.57	16.53	62.17	63.10	54.35	28.40	22.82	26.80	5.58	15.60	16.69	21.70			2.90
813	59.05	66.20	74.66	16.53	61.39	62.48	53.88	27.58	22.65	26.70	5.57	15.60	16.69	21.60			2.90
825	58.43	65.43	73.74	16.53	60.77	61.86	53.25	26.92	22.65	26.70	5.57	15.60	16.69	21.60			2.90
836	57.65	64.81	72.82	16.53	59.99	61.08	52.66	26.96	22.36	26.40	5.56	15.60	16.73	21.40			2.90
849	57.06	64.38	72.40	16.57	59.25	60.18	52.19	27.62	22.20	26.20	5.55	15.50	17.23	21.30			2.90
860	56.27	63.60	71.94	16.57	58.47	59.56	51.55	26.64	22.20	25.80	5.55	15.50	16.90	21.30			2.90
871	55.80	62.83	71.17	16.57	57.68	58.78	51.24	27.62	22.20	25.90	5.54	15.50	17.23	21.20			2.90
883	55.18	62.21	69.94	16.57	57.06	58.31	50.61	27.62	22.03	25.70	5.54	15.50	17.40	21.10			2.90

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

894	54.86	61.90	69.17	16.57	56.59	57.53	50.13	26.64	22.03	25.50	5.53	15.50	17.56	20.90		2.90
907	54.23	61.27	68.55	16.57	55.80	56.74	49.66	25.65	22.03	25.20	5.53	15.30	17.23	20.90		2.90
918	53.60	60.81	67.47	16.57	55.18	56.12	49.18	25.16	21.87	25.00	5.52	15.30	17.40	20.80	3.5	2.90
929	53.13	60.03	67.01	16.57	54.55	55.65	48.71	25.16	21.87	25.00	5.52	15.30	17.56	20.70		2.90
941	52.66	59.40	66.39	16.57	54.08	55.02	48.23	24.83	21.54	25.20	5.51	15.30	17.56	20.70		2.90
952	52.19	58.78	65.62	16.57	53.29	54.39	47.91	24.01	21.54	25.50	4.50	15.30	17.58	20.60		2.80
965	51.73	58.33	65.17	16.59	52.99	53.62	47.30	23.86	21.39	25.60	4.49	15.20	17.58	20.50		2.80
976	51.42	57.86	64.55	16.59	52.36	53.15	46.98	23.37	21.39	25.60	4.49	15.20	17.58	20.50		2.80
987	50.78	57.39	64.24	16.59	51.73	52.68	46.50	23.21	21.39	25.60	4.48	15.20	17.58	20.30		2.80
999	50.47	56.92	63.62	16.59	51.42	52.20	46.19	23.70	21.39	25.60	4.48	15.20	17.58	20.30		2.80
1010	49.99	56.14	63.47	16.59	50.94	51.73	45.71	23.37	21.39	25.50	4.48	15.20	17.42	20.30		2.80
1021	49.50	55.65	62.98	16.57	50.45	51.24	45.37	23.02	21.21	25.30	4.47	15.20	17.56	20.20		2.80
1035	49.02	55.02	62.05	16.57	49.97	50.61	44.89	22.36	21.21	25.10	4.47	15.10	17.56	20.10		2.80
1046	48.71	54.86	61.27	16.57	49.66	50.13	44.57	21.87	21.21	25.20	4.47	15.10	17.56	20.10		2.80
1057	48.23	54.08	60.81	16.57	49.18	49.82	44.26	22.03	21.21	25.10	4.46	15.10	17.56	20.10		2.80
1076	47.76	53.60	60.34	16.57	48.39	49.02	43.62	21.21	21.21	25.10	4.46	15.10	17.73	20.00		2.80
1089	47.12	53.29	59.40	16.57	47.91	48.71	43.14	21.21	21.04	25.60	4.46	15.10	17.90	19.80		2.80
1100	46.96	52.66	58.78	16.57	47.44	48.23	42.82	21.54	21.04	25.30	4.45	15.10	17.73	19.80		2.80
1111	46.48	52.50	58.47	16.57	47.28	47.91	42.50	20.55	21.04	25.10	4.45	15.00	17.73	19.70		2.80
1123	46.17	52.19	58.00	16.57	46.96	47.44	42.18	20.05	21.04	25.00	4.45	15.00	17.90	19.70	3	2.80
1134	45.69	51.71	58.00	16.57	46.48	47.12	41.86	20.88	20.88	25.10	4.45	15.00	17.92	19.70		2.80
1147	45.55	51.42	58.02	16.59	46.19	46.66	41.40	20.40	20.90	25.20	3.14	15.00	17.75	19.60		2.70
1158	45.23	50.94	58.02	16.59	45.71	46.50	41.24	20.24	20.90	25.20	3.14	15.00	17.75	19.60		2.70
1169	44.91	50.63	57.55	16.59	45.55	46.19	40.92	20.07	20.90	25.00	3.14	15.00	17.58	19.60		2.70
1181	44.75	50.15	57.08	16.59	45.23	46.03	40.43	19.41	20.90	24.90	3.14	15.00	17.58	19.50		2.70
1192	44.43	49.99	56.76	16.59	44.75	45.55	40.27	20.07	20.90	24.70	3.14	14.80	17.40	19.50		2.70
1205	43.94	49.66	56.12	16.57	44.57	45.21	39.93	20.22	20.88	24.90	3.13	14.80	17.73	19.50		2.70
1216	43.78	49.18	55.80	16.57	44.26	44.89	39.61	20.05	20.88	24.60	3.13	14.80	17.73	19.40		2.70
1227	43.46	48.87	55.02	16.57	43.94	44.57	39.29	20.38	20.55	24.50	3.13	14.80	18.39	19.40		2.70
1239	43.14	48.71	55.02	16.57	43.62	44.26	39.13	20.22	20.55	24.50	3.13	14.80	18.39	19.40		2.70
1250	42.98	48.23	54.86	16.57	43.46	43.94	38.65	20.22	20.55	24.20	3.13	14.80	17.73	19.20		2.70
1261	42.68	48.09	54.25	16.59	43.16	43.80	38.51	19.74	20.40	24.00	3.13	14.80	18.74	19.20		2.70
1275	42.52	47.46	54.09	16.59	43.00	43.64	38.35	19.24	20.40	24.20	3.13	14.80	20.07	19.20		2.70
1286	42.20	47.30	54.09	16.59	42.68	43.16	38.02	19.24	20.40	24.50	3.12	14.70	20.90	19.20		2.70
1297	41.88	47.14	53.47	16.59	42.20	43.00	37.70	19.74	20.40	24.70	3.12	14.70	21.39	19.10		2.70

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

1309	41.72	46.66	52.99	16.59	42.04	42.68	37.54	19.57	20.40	24.90	3.12	14.70	21.56	19.10	2.70
1320	41.40	46.50	52.68	16.59	41.88	42.52	37.38	19.41	20.40	25.00	3.12	14.70	21.39	19.10	2.70
1334	41.08	46.19	52.36	16.59	41.72	42.04	36.90	19.08	20.24	24.90	3.12	14.70	22.05	19.00	2.70
1345	40.92	46.03	51.89	16.59	41.40	41.88	36.73	18.58	20.40	24.70	3.12	14.70	21.56	19.00	2.70
1356	40.76	45.71	51.89	16.59	41.08	41.88	36.57	18.25	20.24	24.70	3.12	14.70	21.56	19.00	2.70
1368	40.43	45.71	51.89	16.59	40.92	41.40	36.41	18.58	20.24	24.70	3.12	14.60	21.89	19.00	2.70
1379	40.27	45.71	51.57	16.59	40.92	41.40	36.25	18.25	20.24	24.90	3.12	14.60	22.22	18.90	2.70
1392	40.11	45.23	51.42	16.59	40.43	41.24	35.93	18.58	20.07	24.90	3.11	14.60	22.22	18.90	2.70
1403	39.95	44.75	51.26	16.59	40.27	41.08	35.77	18.74	20.07	24.90	3.11	14.60	21.39	18.90	2.70
1414	39.63	44.75	50.78	16.59	40.11	40.92	35.60	19.08	20.07	24.90	3.11	14.60	21.56	18.90	2.70
1432	39.31	44.43	50.15	16.59	39.95	40.43	35.44	19.08	20.07	24.90	3.11	14.60	22.20	18.90	2.70
1446	39.13	43.94	49.82	16.57	39.61	40.09	35.10	18.23	20.05	24.60	3.11	14.60	21.37	18.90	2.70
1457	38.97	43.94	49.66	16.57	39.45	40.09	34.94	18.39	20.05	24.10	3.11	14.60	19.72	18.70	2.70
1468	38.65	43.78	49.18	16.57	39.29	39.93	34.78	17.73	20.05	24.00	4.40	14.50	19.39	18.70	2.80
1480	38.49	43.62	49.18	16.57	39.29	39.45	34.61	17.73	20.05	23.80	3.11	14.50	19.39	18.60	2.70
1491	38.33	43.46	49.18	16.57	39.13	39.29	34.45	17.73	20.05	23.80	3.10	14.50	18.72	18.70	2.70
1502	38.18	43.16	49.04	16.59	38.99	39.31	34.47	17.58	20.07	23.40	3.10	14.50	18.58	18.60	2.70
1516	38.02	42.84	49.04	16.59	38.67	38.99	34.15	17.75	19.74	24.10	3.10	14.50	18.41	18.60	2.70
1527	37.70	42.84	48.73	16.59	38.51	38.99	33.99	17.58	19.74	24.00	3.10	14.50	17.75	18.60	2.70
1538	37.70	42.68	48.41	16.59	38.51	38.67	33.99	17.92	19.74	23.60	3.10	14.50	17.58	18.60	2.70
1550	37.54	42.52	48.41	16.59	38.35	38.51	33.82	17.92	19.74	23.50	3.10	14.50	17.58	18.50	2.70
1561	37.54	42.20	48.41	16.59	38.18	38.35	33.66	18.41	19.74	23.40	3.10	14.50	17.42	18.50	2.70
1575	37.38	42.04	48.09	16.59	38.18	38.35	33.34	18.41	19.74	23.80	3.10	14.40	17.25	18.50	2.70
1586	37.22	42.04	47.46	16.59	38.02	38.18	33.34	18.41	19.74	24.40	3.10	14.40	17.58	18.50	2.70
1597	37.22	42.04	47.46	16.59	37.70	38.18	33.18	18.41	19.74	24.90	3.10	14.40	17.42	18.50	2.70
1609	36.90	42.04	47.78	16.59	37.70	38.02	33.18	17.92	19.74	24.60	3.10	14.40	17.25	18.50	2.70
1620	36.73	41.88	47.30	16.59	37.54	37.70	33.01	18.25	19.74	24.60	3.10	14.40	17.25	18.50	2.70
1633	36.73	41.40	47.14	16.59	37.54	37.54	33.01	17.75	19.74	24.70	3.10	14.40	17.25	18.40	2.70
1644	36.57	41.40	47.30	16.59	37.38	37.54	33.18	17.58	19.57	24.90	3.10	14.40	17.58	18.40	2.70
1655	36.41	41.24	46.66	16.59	37.22	37.22	32.69	17.58	19.57	25.20	3.09	14.40	17.58	18.40	2.70
1667	36.41	41.08	46.35	16.59	36.90	37.22	32.20	17.58	19.57	25.50	3.09	14.40	17.42	18.40	2.70
1678	36.25	41.08	46.35	16.59	36.90	36.88	32.18	17.73	19.55	25.50	3.09	14.40	17.23	18.40	2.70
1692	36.23	40.74	46.48	16.57	36.71	36.88	32.02	17.56	19.55	25.60	3.09	14.40	17.23	18.40	2.70
1703	35.91	40.42	46.48	16.57	36.71	36.71	32.83	17.23	19.55	25.80	3.09	14.20	17.40	18.40	2.70
1714	35.91	40.42	46.17	16.57	36.55	36.71	32.67	17.40	19.39	26.10	3.09	14.20	17.40	18.40	2.70

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

1726	35.75	40.25	46.33	16.57	36.39	36.55	32.83	17.56	19.39	26.80	3.09	14.20	17.73	18.40		2.70
1737	35.58	40.09	46.01	16.57	36.39	36.39	34.61	17.54	19.37	26.80	3.09	14.20	17.71	18.30	2.5	2.70
1750	35.57	40.24	46.31	16.55	36.37	36.37	34.59	17.54	19.37	26.20	3.09	14.20	17.54	18.30		2.70
1761	35.57	40.24	45.99	16.55	36.21	36.37	34.59	17.38	19.37	26.10	3.09	14.20	17.21	18.30		2.70
1772	35.40	40.08	45.67	16.55	36.21	36.21	34.43	17.38	19.37	26.30	3.09	14.20	17.38	18.30		2.70
1791	35.08	39.91	45.35	16.55	35.89	35.89	34.43	17.38	19.37	26.40	3.09	14.20	17.88	18.30		2.70
1802	35.10	39.93	45.53	16.57	35.91	35.91	34.13	16.90	19.39	27.30	3.09	14.10	18.56	18.30		2.70
1816	34.94	39.61	45.53	16.57	35.75	35.75	34.13	17.40	19.39	27.90	3.09	14.20	18.23	18.30		2.70
1827	34.94	39.61	45.37	16.57	35.58	35.75	33.97	17.40	19.39	27.80	3.09	14.10	17.73	18.30		2.70
1838	34.94	39.45	45.21	16.57	35.58	35.58	33.97	16.73	19.39	27.30	3.09	14.10	17.56	18.10		2.70
1850	34.78	39.45	45.21	16.57	35.58	35.58	33.80	17.40	19.39	27.70	3.09	14.10	17.56	18.10		2.70
1861	34.78	39.31	44.75	16.59	35.44	35.44	33.82	16.92	19.24	27.40	3.09	14.10	17.58	18.10		2.70
1875	34.63	39.31	44.75	16.59	35.44	35.44	33.66	16.92	19.24	27.70	3.09	14.10	17.42	18.10		2.70
1886	34.63	39.15	44.43	16.59	35.12	35.12	33.66	17.42	19.24	27.70	3.08	14.10	17.58	18.10		2.70
1897	34.63	39.15	44.43	16.59	35.12	35.12	33.34	16.92	19.24	28.10	3.08	14.10	17.75	18.10		2.70
1909	34.47	38.99	44.43	16.59	34.96	34.96	33.34	16.75	19.08	28.10	3.08	14.10	17.92	18.10		2.70
1920	34.47	38.67	44.27	16.59	34.96	34.96	33.18	16.75	19.24	27.90	3.08	14.10	17.75	18.10		2.70
1933	34.15	38.67	44.27	16.59	34.80	34.80	33.18	16.92	19.08	27.90	0.00	14.10	18.25	18.10		2.60
1944	34.15	38.67	43.80	16.59	34.80	34.80	33.01	16.92	19.08	27.40	3.08	14.10	17.92	18.00		2.70
1955	33.99	38.51	43.80	16.59	34.63	34.80	33.01	17.42	19.08	27.20	0.00	14.00	17.58	18.00		2.60
1967	33.99	38.67	44.27	16.59	34.80	34.80	33.01	16.75	19.08	26.90	0.00	14.00	18.25	18.00		2.60
1978	33.82	38.35	43.96	16.59	34.63	34.49	33.03	16.61	19.10	26.70	0.00	14.00	17.77	18.00		2.60
1992	33.84	38.36	43.81	16.61	34.65	34.65	32.87	16.77	19.10	26.80	3.08	14.00	17.77	18.00		2.70
2003	33.84	38.36	43.81	16.61	34.49	34.65	32.87	17.27	19.10	26.90	0.00	14.00	17.60	18.00		2.60
2014	33.68	38.36	43.81	16.61	34.49	34.49	32.71	16.94	19.10	26.90	0.00	14.00	17.60	18.00		2.60
2026	33.68	38.20	43.66	16.61	34.49	34.49	32.87	16.61	19.10	27.00	3.08	14.00	18.60	18.00		2.70
2037	33.68	38.20	43.66	16.61	34.17	34.17	32.71	16.77	19.10	26.90	3.08	14.00	18.27	18.00		2.70
2050	33.36	38.20	43.50	16.61	34.17	34.17	32.38	16.77	19.10	26.70	3.08	14.00	17.94	18.00		2.70
2061	33.36	38.20	43.18	16.61	34.17	34.17	32.38	16.77	19.10	26.70	3.08	14.00	17.94	18.00		2.70
2072	33.20	38.20	43.18	16.61	34.01	34.01	32.38	16.77	19.10	26.30	0.00	14.00	18.27	18.00		2.60
2084	33.20	38.04	43.18	16.61	34.01	34.01	32.38	16.94	19.10	25.90	3.08	14.00	17.77	17.90		2.70
2095	33.20	37.72	43.02	16.61	34.01	34.01	32.22	16.77	19.10	25.70	0.00	13.90	17.94	17.90		2.60
2108	33.03	37.72	43.18	16.61	33.84	33.84	32.22	16.77	19.10	26.30	0.00	13.90	18.43	17.90		2.60
2119	33.03	37.72	43.18	16.61	33.84	33.84	32.22	16.77	19.10	26.30	3.08	13.90	18.27	17.90		2.70
2130	33.03	37.56	43.18	16.61	33.84	33.84	32.06	16.77	19.10	26.20	0.00	13.90	18.27	17.90		2.60

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

2149	32.87	37.56	42.86	16.61	33.68	33.68	32.06	16.77	18.76	26.10	0.00	13.90	17.77	17.90	2.60
2160	32.87	37.40	42.86	16.61	33.68	33.68	32.06	16.77	18.76	26.10	0.00	13.90	17.60	17.90	2.60
2173	32.71	37.40	42.70	16.61	33.68	33.68	32.06	16.77	18.76	25.80	3.08	13.90	17.44	17.90	2.70
2184	32.71	37.24	42.86	16.61	33.68	33.68	32.06	17.44	18.60	25.80	3.08	13.90	17.27	17.90	2.70
2195	32.71	37.24	42.86	16.61	33.36	33.68	31.90	17.44	18.60	25.80	0.00	13.90	17.44	17.90	2.60
2207	32.71	37.24	43.02	16.61	33.36	33.36	31.90	16.94	18.60	25.90	0.00	13.90	17.60	17.90	2.60
2218	32.38	37.24	43.02	16.61	33.36	33.23	31.94	16.81	18.64	26.20	0.00	13.90	17.48	17.90	2.60
2231	32.42	37.28	43.05	16.65	33.40	33.23	31.61	16.81	18.64	26.20	0.00	13.90	17.48	17.90	2.60
2242	32.42	37.28	42.89	16.65	33.23	33.23	31.61	16.65	18.64	26.30	0.00	13.90	17.31	17.90	2.60
2253	32.42	37.28	42.89	16.65	33.23	33.07	31.61	16.65	18.64	26.40	0.00	13.90	18.47	17.80	2.60
2265	32.26	36.95	42.57	16.65	33.23	33.07	31.45	16.65	18.64	26.60	0.00	13.70	18.31	17.80	2.60
2276	32.26	36.95	42.73	16.65	33.23	33.07	31.45	16.65	18.64	27.00	3.07	13.70	18.47	17.80	2.70
2290	32.26	36.79	42.73	16.65	33.07	33.07	31.45	16.98	18.64	26.40	3.07	13.70	17.97	17.80	2.70
2301	32.26	36.79	42.57	16.65	33.07	33.07	31.45	16.81	18.47	26.20	0.00	13.70	17.64	17.80	2.60
2312	32.10	36.63	42.57	16.65	33.07	33.07	31.45	16.81	18.47	25.80	3.07	13.70	17.64	17.80	2.70
2324	32.10	36.47	42.57	16.65	33.07	33.07	31.45	17.31	18.31	25.80	3.07	13.70	17.48	17.80	2.70
2335	32.10	36.47	42.25	16.65	32.91	33.07	31.45	17.48	18.31	25.30	3.07	13.70	17.25	17.80	2.70
2348	32.04	36.25	42.20	16.59	32.85	33.01	31.39	17.42	17.92	24.60	3.07	13.70	16.92	17.80	2.70
2359	31.88	36.25	42.20	16.59	33.01	33.01	31.39	17.25	17.92	24.70	3.07	13.70	16.92	17.80	2.70
2370	31.88	36.25	42.20	16.59	32.85	33.01	31.39	17.42	17.92	24.70	3.07	13.70	17.42	17.80	2.70
2382	31.88	35.93	42.52	16.59	32.85	32.85	31.23	17.42	17.92	24.40	0.00	13.70	16.92	17.80	2.60
2393	31.88	36.25	42.04	16.59	32.85	32.85	31.23	16.75	17.92	24.20	0.00	13.70	16.92	17.60	2.60
2406	31.55	36.41	42.04	16.59	32.85	32.85	31.23	16.75	18.25	24.60	0.00	13.70	16.59	17.80	2.60
2417	31.55	36.41	42.04	16.59	32.85	32.69	31.06	16.75	18.25	24.60	0.00	13.70	16.59	17.80	2.60
2428	31.55	36.41	42.04	16.59	32.85	32.69	31.06	16.92	18.25	24.60	0.00	13.60	16.75	17.60	2.60
2440	31.55	36.25	42.20	16.59	32.69	32.69	31.06	17.58	17.92	24.40	3.07	13.70	16.75	17.60	2.70
2451	31.55	35.93	42.20	16.59	32.69	32.69	31.06	17.58	17.92	24.50	0.00	13.70	16.92	17.60	2.60
2462	31.35	35.89	41.84	16.55	32.65	32.65	31.02	17.38	17.88	24.60	0.00	13.60	16.71	17.60	2.60
2476	31.35	36.21	42.00	16.55	32.65	32.65	31.02	16.71	17.88	24.70	ERR	13.70	17.21	17.60	2.50
2487	31.35	35.89	42.00	16.55	32.65	32.32	31.02	16.71	17.88	24.50	0.00	13.60	16.88	17.60	2.60
2505	31.35	35.73	42.00	16.55	32.65	32.32	30.86	16.55	17.88	24.40	0.00	13.60	16.71	17.60	2.60
2517	31.35	35.89	41.84	16.55	32.65	32.32	30.86	16.73	17.90	24.10	0.00	13.60	16.90	17.60	2.60
2530	31.37	35.75	41.70	16.57	32.34	32.34	30.88	16.57	17.90	23.80	0.00	13.60	17.23	17.60	2.60
2541	31.21	35.75	41.70	16.57	32.34	32.34	30.88	16.57	17.90	23.60	0.00	13.60	17.40	17.60	2.60
2552	31.21	35.91	41.38	16.57	32.34	32.18	30.88	16.73	17.90	23.60	0.00	13.60	17.56	17.60	2.60

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

2564	31.21	35.91	41.86	16.57	32.34	32.34	30.88	16.73	17.90	23.80	0.00	13.60	17.56	17.60		2.60
2575	31.21	35.91	41.86	16.57	32.34	32.18	30.56	16.57	17.90	24.00	0.00	13.60	17.54	17.50		2.60
2588	31.19	35.89	41.68	16.55	32.32	32.16	30.54	16.71	17.88	23.90	0.00	13.60	17.21	17.50		2.60
2599	31.19	35.89	41.68	16.55	32.16	32.16	30.54	16.55	17.88	23.80	0.00	13.60	16.88	17.50		2.60
2610	31.02	35.73	42.00	16.55	32.16	32.00	30.54	16.71	18.21	23.90	0.00	13.60	17.21	17.50		2.60
2622	31.02	35.89	42.00	16.55	32.16	32.16	30.37	16.88	18.21	24.00	0.00	13.50	17.21	17.50		2.60
2633	31.02	35.89	42.00	16.55	32.16	32.00	30.37	16.71	18.21	24.40	0.00	13.50	17.19	17.50		2.60
2646	31.00	36.19	41.98	16.53	32.14	31.98	30.35	16.36	18.19	24.60	0.00	13.50	16.86	17.50		2.60
2657	31.00	35.87	41.98	16.53	32.14	31.98	30.35	16.36	17.86	24.90	0.00	13.50	17.19	17.50		2.60
2668	31.00	35.87	41.82	16.53	32.14	32.14	30.35	16.36	17.86	24.90	0.00	13.50	17.52	17.50		2.60
2680	31.00	35.87	42.14	16.53	32.14	31.98	30.35	16.36	17.86	24.70	0.00	13.50	17.36	17.50		2.60
2691	31.00	35.87	42.14	16.53	31.98	31.98	30.35	16.36	17.86	24.60	0.00	13.50	17.36	17.50		2.60
2702	31.00	35.71	41.98	16.53	31.98	31.98	30.19	16.53	17.86	24.60	0.00	13.50	17.36	17.50		2.60
2716	31.00	35.87	41.98	16.53	31.98	31.98	30.35	16.36	17.86	24.60	0.00	13.50	17.52	17.50		2.60
2727	31.00	35.71	41.34	16.53	31.98	31.82	30.19	16.03	17.86	24.40	0.00	13.50	17.52	17.50		2.60
2738	30.84	35.71	41.34	16.53	31.98	31.98	30.19	16.03	17.86	24.40	0.00	13.50	17.69	17.50		2.60
2750	30.84	35.71	41.34	16.53	31.98	31.82	30.19	16.03	17.86	24.20	0.00	13.50	18.35	17.50		2.60
2761	30.84	35.73	41.36	16.55	32.00	31.84	30.21	16.38	17.88	24.10	0.00	13.50	17.88	17.50		2.60
2775	30.86	35.57	41.04	16.55	32.00	31.84	30.21	16.71	17.88	24.00	0.00	13.50	17.54	17.50		2.60
2786	30.86	35.57	41.20	16.55	32.00	32.00	30.21	16.71	17.88	23.80	0.00	13.50	17.54	17.50		2.60
2797	30.86	35.57	41.20	16.55	32.00	32.00	30.21	16.71	17.88	23.50	0.00	13.50	17.54	17.50		2.60
2809	30.86	35.57	41.36	16.55	32.00	31.84	30.21	16.55	17.88	23.80	0.00	13.50	18.21	17.50		2.60
2820	30.86	35.57	41.36	16.49	31.94	31.78	30.15	16.65	17.82	23.40	0.00	13.50	17.48	17.50		2.60
2833	30.48	35.51	41.62	16.49	31.78	31.78	30.15	16.49	17.82	23.10	0.00	13.40	18.15	17.50		2.60
2844	30.48	35.51	41.14	16.49	31.78	31.45	29.99	15.99	17.82	23.10	0.00	13.40	17.48	17.50		2.60
2862	30.48	35.51	41.14	16.49	31.78	31.45	29.99	16.32	17.82	22.80	0.00	13.40	17.32	17.50		2.60
2873	30.48	35.51	41.14	16.49	31.78	31.78	29.66	15.99	17.82	22.50	0.00	13.40	17.36	17.40		2.60
2887	30.52	35.55	41.34	16.53	31.82	31.49	29.54	16.36	17.86	22.50	0.00	13.40	17.19	17.50		2.60
2898	30.52	35.55	41.34	16.53	31.82	31.49	29.38	16.36	17.69	22.70	0.00	13.40	17.19	17.40		2.60
2909	30.52	35.55	41.34	16.53	31.82	31.49	29.21	16.69	17.69	22.80	0.00	13.40	17.19	17.50	2.2	2.60
2920	30.52	35.55	41.66	16.53	31.82	31.49	29.21	16.53	17.69	22.70	0.00	13.40	17.36	17.50		2.60
2932	30.52	35.38	41.34	16.53	31.49	31.33	29.21	16.53	17.69	22.50	0.00	13.40	17.36	17.40		2.60
2943	30.48	35.35	41.62	16.49	31.45	31.29	29.01	16.32	17.65	22.40	0.00	13.40	17.48	17.40		2.60
2957	30.48	35.35	41.78	16.49	31.45	31.29	29.01	16.32	17.65	22.50	0.00	13.40	18.15	17.40		2.60
2968	30.48	35.35	41.62	16.49	31.45	31.29	28.68	16.32	17.65	22.80	0.00	13.40	18.15	17.40		2.60

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

2979	30.48	35.35	41.78	16.49	31.45	31.29	28.68	16.49	17.65	23.00	3.06	13.40	17.82	17.40	2.70
2991	30.48	35.35	41.14	16.49	31.78	31.29	28.68	16.32	17.65	23.30	0.00	13.40	17.48	17.40	2.60
3002	30.48	35.38	41.34	16.53	31.49	31.33	29.05	16.69	17.69	23.10	0.00	13.40	17.36	17.40	2.60
3015	30.52	35.06	41.34	16.53	31.49	31.33	29.05	16.69	17.52	23.10	0.00	13.40	17.19	17.40	2.60
3026	30.35	35.38	41.18	16.53	31.49	31.33	29.05	16.36	17.52	23.10	0.00	13.40	17.19	17.40	2.60
3037	30.52	35.06	41.66	16.53	31.49	31.33	29.05	16.53	17.52	22.80	0.00	13.40	17.19	17.40	2.60
3048	30.35	35.06	41.66	16.53	31.49	31.33	29.05	16.69	17.52	22.80	0.00	13.40	16.86	17.40	2.60
3060	30.35	34.90	41.66	16.53	31.29	31.29	28.68	16.49	17.48	23.00	0.00	13.40	17.15	17.40	2.60
3074	30.31	35.02	41.30	16.49	31.45	31.13	28.68	16.49	17.48	22.90	0.00	13.40	16.82	17.40	2.60
3085	30.31	35.02	41.30	16.49	31.29	31.13	28.68	16.32	17.48	22.90	0.00	13.40	17.15	17.40	2.60
3096	30.31	35.02	41.30	16.49	31.29	31.29	28.68	16.65	17.48	22.90	0.00	13.30	17.32	17.40	2.60
3108	30.31	35.02	41.30	16.49	31.29	31.13	28.68	16.49	17.48	23.00	0.00	13.40	17.32	17.40	2.60
3119	30.31	35.35	41.30	16.49	31.29	31.17	28.72	16.53	17.52	22.80	0.00	13.30	17.19	17.40	2.60
3132	30.35	35.06	41.18	16.53	31.33	31.17	28.72	16.53	17.52	22.40	0.00	13.30	16.86	17.40	2.60
3143	30.35	35.06	41.18	16.53	31.33	31.17	28.72	16.53	17.52	22.40	0.00	13.30	16.69	17.40	2.60
3154	30.35	35.06	41.66	16.53	31.33	31.17	28.72	16.69	17.52	22.40	0.00	13.30	16.69	17.40	2.60
3166	30.35	35.38	41.82	16.53	31.33	31.17	28.56	16.69	17.52	22.50	0.00	13.30	16.86	17.40	2.60
3177	30.35	35.38	41.66	16.53	31.33	31.17	28.72	16.53	17.52	22.40	0.00	13.30	16.86	17.40	2.60
3191	30.35	35.06	41.98	16.53	31.33	31.17	28.72	16.36	17.52	22.40	0.00	13.30	17.19	17.40	2.60
3202	30.35	34.90	41.66	16.53	31.33	31.17	28.72	16.03	17.52	22.50	0.00	13.30	17.19	17.40	2.60
3220	30.35	34.90	41.82	16.53	31.33	31.17	28.72	16.53	17.52	22.90	0.00	13.30	16.86	17.30	2.60
3231	30.35	34.90	41.82	16.53	31.33	31.17	28.72	16.36	17.52	22.90	3.06	13.30	17.19	17.30	2.70
3243	30.35	34.90	41.98	16.53	31.33	31.17	28.72	16.36	17.52	22.50	0.00	13.30	16.86	17.30	2.60
3256	30.35	34.90	41.82	16.53	31.33	31.33	28.72	16.69	17.52	22.20	0.00	13.30	16.86	17.30	2.60
3267	30.35	34.90	41.34	16.53	31.33	31.17	28.72	16.53	17.36	21.90	0.00	13.30	17.19	17.30	2.60
3278	30.35	34.90	41.82	16.53	31.33	31.17	28.72	16.36	17.36	22.00	0.00	13.30	16.86	17.30	2.60
3290	30.19	34.90	41.98	16.53	31.17	31.17	28.72	16.36	17.36	22.20	0.00	13.30	16.69	17.30	2.60
3301	30.35	34.90	41.98	16.49	31.13	31.13	28.52	16.49	17.32	22.20	0.00	13.30	16.82	17.30	2.60
3314	30.31	34.86	41.78	16.49	31.13	31.13	28.52	16.32	17.48	22.40	0.00	13.30	17.15	17.30	2.60
3325	30.15	34.86	41.62	16.49	31.13	31.13	28.36	16.49	17.48	22.30	0.00	13.30	17.32	17.30	2.60
3336	30.15	35.02	41.78	16.49	31.29	31.13	28.52	16.49	17.48	22.30	0.00	13.30	17.15	17.30	2.60
3348	30.15	35.02	41.94	16.49	31.13	30.97	28.36	16.49	17.48	22.70	0.00	13.30	16.82	17.30	2.60
3359	30.15	35.02	41.78	16.49	31.13	31.00	28.40	16.36	17.52	22.40	0.00	13.30	16.86	17.30	2.60
3372	30.19	35.06	42.14	16.53	31.17	31.00	28.56	15.86	17.52	22.30	0.00	13.30	16.69	17.30	2.60
3383	30.19	35.06	41.98	16.53	31.17	31.00	28.56	16.03	17.52	22.40	3.06	13.30	16.69	17.30	2.70

DAMPER FIELD TEST NO. 2:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

3394	30.19	34.90	42.14	16.53	31.17	31.17	28.56	16.36	17.36	22.40	0.00	13.30	16.69	17.30		2.60
3406	30.19	34.90	41.98	16.53	31.17	31.00	28.56	16.53	17.36	22.30	0.00	13.30	16.53	17.30		2.60
3417	30.19	34.90	42.14	16.53	31.17	31.17	28.56	16.03	17.32	22.20	0.00	13.30	16.49	17.30		2.60
3431	30.15	35.02	41.94	16.49	31.13	31.13	28.52	16.32	17.32	22.20	0.00	13.30	17.15	17.30		2.60
3442	30.15	35.02	41.62	16.49	31.13	30.97	28.52	16.32	17.32	21.90	0.00	13.10	17.48	17.30		2.60
3453	30.15	34.86	41.30	16.49	31.13	30.97	28.36	16.32	17.32	22.00	0.00	13.10	17.48	17.30		2.60
3464	30.15	35.02	41.62	16.49	31.13	30.97	28.52	15.99	17.32	22.20	0.00	13.10	17.48	17.30		2.60
3476	30.15	34.86	41.30	16.49	31.13	30.97	28.52	16.32	17.32	22.00	0.00	13.10	17.36	17.30		2.60
3489	30.19	34.90	41.66	16.53	31.00	31.00	28.56	16.03	17.52	21.80	0.00	13.10	17.52	17.30		2.60
3500	30.19	34.90	41.98	16.53	31.17	31.00	28.40	16.36	17.36	21.70	0.00	13.10	17.69	17.30		2.60
3511	30.19	34.90	41.34	16.53	31.17	31.00	28.40	16.03	17.52	21.40	0.00	13.10	17.52	17.30		2.60
3523	30.19	34.90	41.18	16.53	31.00	31.00	28.40	16.03	17.52	21.20	0.00	13.10	17.36	17.30		2.60
3534	30.19	34.90	40.86	16.53	31.17	31.00	28.23	16.36	17.52	21.20	0.00	13.10	17.19	17.30		2.60
3547	30.19	34.90	41.18	16.53	31.17	31.00	28.23	16.03	17.52	21.20	0.00	13.10	16.86	17.30		2.60
3558	30.19	34.90	41.02	16.53	31.00	30.84	27.91	16.03	17.52	21.10	0.00	13.10	16.86	17.30		2.60
3576	30.19	35.06	41.82	16.53	31.00	30.84	28.23	16.03	17.52	21.40	0.00	13.10	17.19	17.30		2.60
3588	30.03	35.06	41.66	16.53	31.17	30.84	28.23	16.03	17.52	21.40	0.00	13.10	17.19	17.30		2.60
3599	30.03	34.90	41.34	16.53	31.17	30.80	28.19	16.32	17.32	21.60	0.00	13.10	17.48	17.30	2.2	2.60

DAMPER FIELD TEST NO. 3:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

Sheltair Scientific Ltd. Field Test Data April 1-2,1987

Taken from Phil Porter's house on W. 13th Ave., Vancouver

Legend:

t1: Post-mixing flue wall temperature, C
t2: Post-mixing flue gas temp, C
t3: Breech gas temp, C
t4: Reference temp, C
t5: Temp. of flue gas 10 cm beyond b. damper, 1 cm below top side of flue, C
t6: Flue gas temp 10 cm beyond b. damper, center of stream, C
t7: Flue wall temp 10 cm beyond b. damper, C
t8: Flue gas temp at thimble, C
t9: Flue wall temp at thimble, C (found not well fixed to wall after test)
t10: First dilution air temp, C *
t11: \
t12: Volumetric chimney flow, l/s (corrected for temperature variation)
t13: Chimney top wall temp, C
t14: Second dilution air temp, C *
t15: Chimney top gas temp, C
p16: Static pressure at chimney thimble, taken manually, Pa

* see attached notes for explanation

Configuration: Ameritherm barometric damper in vent connector.
House Pressure: normal; Outdoor Temperature: 8 C

Time (s)	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t12	t13	t14	t15	p16	Comments	flow press.
0	30.64	32.59	34.53	14.48	29.01	29.17	22.78	19.80	19.97	18.30	ERR	10.20	14.82	16.2		Flow measurement not connected properly	-0.10
14	30.64	32.59	34.53	14.48	29.01	29.17	22.78	19.80	19.97	18.30	ERR	10.20	14.65	16.2		until approx. 210s.	-0.60
25	30.64	32.59	34.70	14.48	29.01	29.17	22.78	19.80	19.97	18.00	ERR	10.20	14.65	16.2			-0.40
36	30.64	32.59	34.37	14.48	29.01	29.33	22.78	19.97	19.97	17.90	ERR	10.30	14.65	16.2			-0.50
47	30.64	32.59	34.37	14.48	29.01	29.17	22.78	19.80	19.97	17.60	ERR	10.30	14.65	16.2			-0.50

DAMPER FIELD TEST NO. 3:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

59	34.21	53.21	54.78	14.48	41.62	39.85	23.76	21.79	20.13	32.70	ERR	10.20	27.21	16.3		Burner on.	-0.70
72	83.58	132.03	99.58	14.48	73.39	79.95	30.64	36.64	27.37	52.10	ERR	10.30	24.75	16.6			-1.90
83	115.00	159.77	120.52	14.48	107.55	117.18	42.74	61.66	37.12	60.90	ERR	10.60	22.45	18.9			-3.30
94	134.03	168.85	129.31	14.48	130.31	138.88	53.05	74.31	47.04	56.20	ERR	11.80	20.13	23.5			-4.10
106	146.54	169.41	135.75	14.48	144.14	150.50	62.44	81.62	57.76	51.00	ERR	13.10	18.48	27			-4.10
117	155.00	171.50	137.03	14.50	154.45	159.09	74.02	89.92	66.33	46.20	ERR	14.40	17.33	29.4			-4.40
131	161.75	174.30	137.76	14.50	163.15	166.22	85.56	96.34	72.80	42.60	ERR	15.30	16.50	32.1		Fan on.	-4.50
142	166.92	175.41	134.19	14.50	168.31	170.54	94.70	100.64	77.23	39.50	ERR	16.10	15.84	34.9			-4.70
153	170.68	176.80	129.90	14.50	171.66	173.60	102.26	104.33	80.72	36.90	ERR	16.70	15.67	37.1	14.5		-4.80
165	172.49	176.80	130.62	14.50	175.13	176.38	109.18	106.68	83.75	35.00	ERR	17.00	15.50	39			-4.80
176	175.27	177.36	129.47	14.50	177.91	179.06	115.06	109.95	86.36	33.20	ERR	17.60	15.39	40.8			-4.90
190	177.54	177.81	129.94	14.55	180.59	180.73	119.71	110.98	89.06	31.70	ERR	18.10	15.39	42.4			-4.90
201	176.84	179.06	135.09	14.55	182.53	182.25	121.45	114.77	90.71	30.60	12.99	18.40	15.39	43.6			3.70
212	177.81	180.03	137.52	14.55	183.77	183.22	119.27	115.93	93.11	29.90	30.94	18.60	15.39	44.7		Flow measurement connected.	9.30
224	180.59	181.42	136.52	14.55	185.57	184.88	119.27	117.53	95.64	29.10	31.23	19.10	15.39	45.8			9.40
235	179.89	182.11	133.09	14.55	187.51	186.27	120.18	118.00	98.65	28.30	30.82	19.50	15.59	46.9			9.20
249	179.23	184.36	132.70	14.59	188.93	187.68	121.77	119.89	99.53	27.80	31.55	19.70	15.59	47.8			9.50
260	180.20	184.50	139.69	14.59	189.20	188.51	122.93	122.20	100.27	27.20	31.58	20.00	15.59	48.5			9.50
271	183.25	184.78	141.53	14.59	190.17	189.48	123.94	123.79	101.46	26.80	32.28	20.20	15.59	49.4	17.5		9.80
283	184.78	183.95	138.12	14.59	191.41	190.86	124.95	124.66	103.08	26.40	32.33	20.50	15.43	50			9.80
294	185.88	184.50	137.55	14.59	191.97	191.41	125.95	125.02	104.78	26.10	32.13	20.70	15.52	50.6	18		9.70
308	185.96	186.51	139.48	14.68	192.45	192.32	127.33	125.60	105.37	25.60	32.82	21.10	15.52	51.2			10.00
319	187.48	186.93	138.34	14.68	193.15	192.32	128.19	126.17	106.11	25.10	32.82	21.30	15.52	51.6			10.00
330	187.06	187.20	138.48	14.68	193.97	192.18	128.62	127.61	107.28	25.00	32.60	21.60	15.68	52.2			9.90
342	186.23	185.68	138.77	14.68	194.53	193.01	128.76	129.77	107.28	24.90	33.28	21.70	15.68	52.6			10.20
361	187.69	187.97	140.41	14.77	193.91	193.22	129.27	128.98	108.68	24.60	33.29	22.00	15.77	53.5	18.5		10.20
375	186.59	188.52	141.26	14.77	194.88	193.91	128.98	129.84	109.41	24.50	33.31	22.30	15.77	53.9			10.20
386	187.00	188.66	136.99	14.77	195.43	194.88	129.27	131.71	110.44	24.70	33.56	22.40	15.77	54.1			10.30
397	187.14	189.08	130.13	14.77	196.53	194.88	129.84	130.99	111.17	24.90	34.41	22.70	15.77	54.5			10.70
409	188.66	189.21	128.84	14.77	195.43	194.60	130.13	130.28	112.05	24.90	33.98	22.90	15.77	54.9			10.50
420	189.67	190.08	132.04	14.82	195.61	194.50	130.17	130.46	112.53	25.00	33.98	23.00	15.82	55.2			10.50
434	187.60	186.90	131.32	14.82	191.19	186.21	129.31	124.13	110.63	24.90	28.92	23.00	15.99	55.2			8.40
445	166.21	130.32	99.29	14.82	145.56	147.96	122.26	103.14	98.41	25.20	24.71	22.30	17.99	52.6			7.20
456	148.38	130.89	89.16	14.82	139.03	138.89	115.15	94.99	91.40	25.50	23.38	21.10	18.32	50.1			6.80
468	135.75	127.30	85.25	14.82	133.75	132.75	108.58	90.21	86.60	25.70	22.10	20.30	17.99	48.2			6.40

DAMPER FIELD TEST NO. 3:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

479	127.16	123.56	87.74	14.91	128.82	127.52	102.48	85.93	82.31	25.80	20.50	19.70	18.90	46.2		5.90
493	119.44	119.59	86.99	14.91	124.36	122.63	98.04	83.22	78.52	25.80	19.77	19.40	18.90	44.6		5.70
504	113.77	115.38	89.24	14.91	119.15	117.56	93.58	80.19	75.62	25.70	19.02	19.10	19.73	43.3	15	5.50
515	108.80	111.44	89.09	14.91	115.09	113.48	89.39	77.15	73.02	25.60	17.95	18.70	19.57	41.8		5.20
527	104.10	108.22	87.74	14.91	110.71	108.80	86.53	75.47	70.11	25.60	17.50	18.50	18.90	40.5		5.10
538	99.82	103.95	86.99	14.91	106.23	104.17	82.84	73.25	67.41	25.50	16.36	18.30	18.82	39.1	14.5	4.80
552	94.39	99.45	85.70	14.99	101.52	99.30	79.35	69.87	64.78	25.30	15.53	18.00	18.49	38		4.60
563	90.96	95.73	84.80	14.99	97.52	95.59	76.46	68.02	62.29	25.50	14.70	17.80	18.49	36.9		4.40
574	87.36	91.86	83.74	14.99	93.50	91.86	73.55	65.40	59.96	25.10	13.84	17.60	17.99	36		4.20
586	84.95	88.11	81.78	14.99	90.36	89.01	70.79	63.85	57.77	24.60	13.37	17.40	17.49	34.9		4.10
597	82.84	86.46	81.62	14.99	88.26	86.97	68.24	61.58	55.96	24.20	13.33	17.30	17.89	33.9		4.10
611	80.93	85.16	80.93	15.06	86.22	85.01	65.93	60.34	54.70	23.90	12.44	17.00	17.73	33.2		3.90
622	79.56	84.11	79.41	15.06	84.41	83.35	64.07	58.31	53.92	23.90	12.41	16.90	17.56	32.5		3.90
633	78.35	82.90	79.11	15.06	82.90	81.84	62.36	56.59	53.13	23.60	11.93	16.80	17.23	31.9	11	3.80
645	77.59	81.99	78.50	15.06	81.69	80.48	60.80	55.49	52.18	23.40	11.44	16.70	17.06	31.4		3.70
656	77.28	81.08	78.20	15.06	80.32	79.41	59.50	54.65	51.34	23.50	11.43	16.70	17.01	30.8		3.70
669	76.77	79.67	77.69	15.17	79.06	77.99	57.94	53.71	50.87	23.40	11.40	16.60	16.84	30.5		3.70
680	76.01	78.75	76.93	15.17	77.69	76.93	56.69	51.97	50.23	23.40	10.90	16.40	16.84	30.1	10	3.60
691	75.25	77.99	76.62	15.17	76.62	75.86	55.59	51.34	49.60	23.30	10.88	16.40	16.51	29.7		3.60
703	74.49	77.38	76.01	15.17	75.40	74.94	54.49	50.08	49.13	23.50	10.87	16.30	16.84	29.4		3.60
721	73.45	75.29	74.67	15.21	73.45	72.99	52.80	48.69	48.21	24.00	10.33	16.20	16.38	28.8	10	3.50
735	72.69	74.52	73.76	15.21	72.07	71.92	51.85	48.21	47.58	24.00	10.32	16.10	16.38	28.5		3.50
746	71.77	73.60	72.99	15.21	71.00	71.00	50.91	47.10	46.94	24.00	9.78	16.10	16.38	28.1		3.40
757	71.15	72.84	72.07	15.21	70.08	70.08	50.11	46.79	46.63	23.90	9.76	15.90	16.21	27.9		3.40
769	70.69	71.77	71.61	15.21	69.15	69.15	49.17	45.83	45.99	24.10	9.75	15.90	16.21	27.7		3.40
780	69.61	71.20	71.04	15.26	67.81	68.27	48.42	44.76	45.40	24.20	9.74	15.80	16.26	27.4		3.40
794	69.04	70.28	69.97	15.26	67.04	67.35	47.63	44.13	44.92	24.20	9.72	15.80	16.26	27.2		3.40
805	67.97	69.35	69.35	15.26	66.11	66.58	46.99	42.69	44.44	24.10	9.71	15.70	16.43	26.9	9.5	3.40
816	67.35	68.58	68.43	15.26	65.18	65.80	46.20	41.57	44.13	24.10	9.70	15.70	16.43	26.7		3.40
828	66.58	67.81	67.66	15.26	64.25	64.87	45.72	41.41	43.65	23.90	9.13	15.70	16.26	26.4		3.30
839	65.80	67.04	67.04	15.30	63.36	63.98	44.96	40.16	43.37	23.90	9.12	15.60	16.30	26.3		3.30
852	64.91	65.99	66.15	15.30	62.58	63.21	44.32	39.68	43.05	23.90	8.52	15.60	16.30	26.2		3.20
863	64.14	65.22	65.69	15.30	61.81	62.58	44.00	39.04	42.57	23.60	9.10	15.60	16.30	25.9		3.30
874	63.36	64.45	64.76	15.30	60.87	61.65	43.37	38.23	42.25	23.30	9.09	15.50	16.30	25.8	9	3.30
886	62.58	63.98	63.98	15.30	60.25	60.87	42.73	37.43	41.77	23.50	9.08	15.50	16.30	25.7		3.30

DAMPER FIELD TEST NO. 3:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

897	61.96	63.21	63.05	15.30	59.31	60.15	42.46	36.84	41.66	23.40	8.48	15.30	16.36	25.6		3.20
911	61.40	62.64	62.33	15.36	58.43	59.37	41.82	36.36	41.34	23.40	8.47	15.30	16.36	25.3		3.20
922	60.62	61.86	61.71	15.36	57.65	58.59	41.50	36.20	40.86	23.10	8.46	15.30	16.20	25.2		3.20
933	59.84	61.55	61.08	15.36	56.87	58.12	40.86	35.55	40.54	23.00	8.46	15.30	16.20	25.1		3.20
945	59.21	60.93	60.93	15.36	56.40	57.49	40.22	35.07	40.22	23.00	8.45	15.20	16.20	24.9		3.20
956	58.59	60.31	60.93	15.36	55.77	56.71	39.90	35.24	40.07	22.90	7.81	15.20	16.04	24.7		3.10
969	58.13	59.69	60.16	15.37	54.99	56.25	39.59	35.07	39.75	22.50	7.81	15.10	15.71	24.6		3.10
980	57.35	59.07	59.38	15.37	54.52	55.47	39.27	34.59	39.27	22.80	7.80	15.20	15.71	24.5		3.10
991	56.56	58.29	59.07	15.37	53.89	54.84	38.95	34.27	38.95	22.90	7.79	15.10	15.54	24.4		3.10
1003	56.25	57.66	58.29	15.37	53.26	54.21	38.78	33.94	38.78	22.80	7.78	15.10	15.54	24.2		3.10
1014	55.62	56.88	57.97	15.37	52.79	53.42	38.46	33.62	38.46	23.00	7.78	15.10	15.54	24.1	8.5	3.10
1027	54.99	56.41	57.19	15.37	52.16	52.95	38.14	33.29	38.14	23.10	7.77	15.00	15.54	24		3.10
1038	54.52	55.78	56.56	15.37	51.53	52.32	37.82	32.64	37.98	23.40	7.76	15.00	15.54	23.9		3.10
1049	53.89	55.47	55.78	15.37	51.06	51.85	37.50	32.64	37.82	23.40	7.76	15.00	15.54	23.8		3.10
1061	53.26	54.84	55.47	15.37	50.42	51.21	37.17	32.48	37.50	23.60	7.75	15.00	15.37	23.8		3.10
1079	52.48	54.21	54.70	15.39	49.65	50.44	36.87	31.85	37.19	24.00	7.07	14.80	15.39	23.5	7	3.00
1092	52.02	53.44	54.07	15.39	49.02	50.13	36.39	31.53	37.03	24.10	7.06	14.80	15.39	23.4		3.00
1103	51.55	53.13	53.91	15.39	48.70	49.49	36.23	31.20	36.87	24.00	7.05	14.80	15.39	23.3		3.00
1114	51.08	52.81	53.44	15.39	48.07	49.02	35.74	31.04	36.55	23.80	7.05	14.80	15.39	23.3		3.00
1126	50.60	52.34	53.13	15.39	47.59	48.70	35.58	30.71	36.39	23.50	7.05	14.70	15.39	23.1		3.00
1137	50.13	52.02	52.81	15.39	47.12	48.40	35.44	30.41	36.08	23.40	7.04	14.70	15.41	23		3.00
1151	49.67	51.41	52.20	15.41	46.82	47.77	35.28	30.08	36.08	23.10	7.04	14.70	15.41	22.9		3.00
1162	49.36	50.78	51.88	15.41	46.34	47.61	35.11	29.92	35.60	23.60	6.29	14.70	15.41	22.8	6.5	2.90
1173	48.88	50.62	51.57	15.41	46.02	46.98	34.63	29.92	35.44	23.90	6.29	14.60	15.41	22.8		2.90
1185	48.56	50.15	51.09	15.41	45.54	46.66	34.47	29.43	35.44	24.10	7.02	14.60	25.50	22.7		3.00
1196	70.41	103.81	77.60	15.41	67.95	77.60	37.37	41.39	39.31	46.20	13.16	14.60	21.88	22.8	Burner on.	4.10
1209	111.44	159.15	111.88	15.41	114.36	124.36	46.66	68.41	50.78	51.80	19.81	15.00	19.90	25.6		5.70
1220	134.26	166.29	123.78	15.41	137.40	144.93	55.03	79.43	64.39	47.30	22.72	16.30	18.57	29.1	10	6.50
1231	148.46	171.02	131.54	15.41	150.72	155.36	65.79	87.89	73.94	43.50	24.93	17.60	17.41	32.3	13.5	7.20
1243	158.31	171.02	133.12	15.41	159.29	163.07	76.23	93.58	80.19	41.00	26.71	18.50	16.75	35.3		7.80
1254	165.59	173.67	127.96	15.41	166.29	169.07	86.38	99.67	85.63	38.80	27.40	19.40	16.47	38.4	15	8.00
1268	171.77	174.41	126.14	15.47	171.63	173.16	95.27	103.86	90.34	36.40	28.50	19.80	16.31	40.7	Fan on.	8.40
1279	174.14	176.64	130.02	15.47	174.41	175.53	101.20	106.95	93.48	34.70	29.06	20.30	15.81	42.7		8.60
1291	177.47	177.19	132.60	15.47	176.91	177.61	106.22	109.88	95.72	33.00	29.60	20.80	15.81	44.3		8.80
1302	178.30	176.91	132.74	15.47	179.13	179.69	110.76	112.81	97.65	31.40	29.67	21.20	15.81	45.7		8.80

DAMPER FIELD TEST NO. 3:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

1313	178.72	179.41	134.03	15.47	180.80	180.66	113.68	114.12	99.43	30.30	30.17	21.40	15.84	47.1			9.00
1327	179.16	179.02	135.48	15.50	182.35	182.21	116.33	116.33	101.53	29.10	30.91	21.90	15.67	48.3	17		9.30
1338	179.44	178.74	133.34	15.50	183.87	183.73	118.51	116.76	103.15	28.10	30.96	22.20	15.67	49.3			9.30
1349	179.16	178.60	131.19	15.50	185.95	185.12	120.10	118.22	104.62	27.30	31.91	22.40	15.67	50.2			9.70
1361	179.02	178.19	129.90	15.50	187.05	186.09	121.98	120.39	105.51	26.80	31.72	22.70	15.67	51			9.60
1372	179.02	179.30	134.77	15.50	187.19	187.19	123.28	120.39	106.98	26.40	32.20	22.90	15.67	51.7			9.80
1384	181.57	181.70	135.25	15.56	188.49	188.49	124.20	122.47	107.76	26.10	32.47	23.10	15.73	52.4	18.5		9.90
1398	182.12	180.87	134.25	15.56	190.01	189.32	125.21	123.91	109.38	25.70	32.50	23.40	15.73	53			9.90
1409	183.09	182.26	130.95	15.56	190.70	189.73	126.22	125.21	110.40	25.50	32.73	23.60	15.90	53.8			10.00
1421	182.95	182.67	126.07	15.56	190.70	189.87	126.79	125.35	110.99	25.30	32.73	23.60	15.73	54.3			10.00
1439	185.31	184.20	128.52	15.56	191.67	191.25	128.41	126.97	112.19	25.10	33.22	24.10	15.94	55.1	19		10.20
1453	184.51	184.23	128.41	15.60	192.80	192.11	128.98	128.69	112.77	25.00	33.03	24.40	15.94	55.5			10.10
1464	185.48	184.92	128.84	15.60	193.08	192.94	129.41	128.69	113.21	25.00	33.28	24.50	15.94	55.9			10.20
1475	183.95	185.48	125.53	15.60	193.08	192.80	130.13	128.84	113.79	25.00	33.27	24.60	15.94	56.2	19.5		10.20
1487	188.24	184.09	122.65	15.60	193.08	192.53	130.42	128.69	114.52	24.90	33.26	24.90	15.94	56.7			10.20
1498	186.45	184.65	121.49	15.60	193.08	192.94	130.85	129.76	115.17	24.90	33.49	25.00	16.01	57	19.5		10.30
1512	187.61	185.26	124.29	15.67	194.38	193.28	131.05	130.33	115.75	25.00	33.93	25.10	16.34	57.2			10.50
1523	189.41	185.40	119.81	15.67	195.21	194.52	130.91	131.34	116.62	25.10	33.33	25.20	16.01	57.6			10.20
1534	189.13	185.26	119.67	15.67	195.35	194.10	131.05	131.19	117.78	25.30	33.75	25.30	16.34	57.7			10.40
1546	186.78	186.37	117.64	15.67	195.48	194.38	131.05	131.77	118.36	25.60	33.97	25.50	16.34	58.1			10.50
1557	188.85	187.33	114.58	15.67	195.35	194.79	131.62	130.48	119.38	25.70	33.77	25.60	16.38	58.3			10.40
1571	185.43	183.21	110.09	15.71	178.78	174.61	129.79	120.14	116.51	25.80	27.57	25.60	16.05	57.9			8.00
1582	161.93	128.79	88.01	15.71	144.76	146.03	122.31	103.04	103.78	25.70	24.13	24.70	16.38	55.1		Burner off.	7.00
1593	144.33	127.35	80.16	15.71	138.37	137.66	115.35	95.93	96.38	25.70	22.80	23.80	16.55	52.8	17		6.60
1622	121.15	119.27	77.12	15.71	126.31	124.43	100.78	85.71	85.56	25.20	19.50	22.40	16.67	48	15.5		5.60
1635	115.16	116.33	77.68	15.83	121.69	119.95	96.34	82.69	82.54	25.00	18.75	22.00	16.67	46.6			5.40
1646	110.20	112.25	77.38	15.83	117.20	115.45	91.86	79.36	79.96	24.90	17.99	21.80	16.83	45.2	14.5		5.20
1657	105.65	109.17	79.36	15.83	112.83	110.64	88.12	77.68	77.23	24.90	17.21	21.40	16.83	43.9			5.00
1669	101.23	105.65	82.39	15.83	108.73	106.39	84.50	75.85	74.94	25.10	16.41	21.20	16.83	42.6			4.80
1680	96.93	101.82	83.90	15.83	104.47	102.26	81.18	73.32	71.94	25.10	15.60	20.90	16.90	41.3	14		4.60
1693	92.82	97.59	84.87	15.90	99.96	97.59	77.60	70.71	69.33	25.10	14.74	20.70	16.90	40.2			4.40
1704	89.23	93.87	85.17	15.90	95.80	93.87	74.70	68.25	66.86	25.30	13.87	20.60	16.90	39.3			4.20
1715	85.77	89.53	82.91	15.90	91.93	90.13	71.63	65.93	64.54	25.70	13.39	20.30	16.90	38.3	13		4.10
1727	82.75	85.92	81.85	15.90	88.48	86.83	69.02	63.14	62.21	25.60	12.47	20.20	16.90	37.3		Fan off.	3.90
1738	80.63	84.11	78.36	15.90	85.92	84.57	66.71	61.43	60.81	25.20	12.43	20.00	16.78	36.4	12.5		3.90

DAMPER FIELD TEST NO. 3:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

1751	78.54	82.94	77.78	15.94	84.00	82.79	64.27	59.91	59.76	25.00	11.95	19.80	16.78	35.7		3.80
1762	77.48	81.28	76.11	15.94	82.34	81.28	62.56	58.20	58.66	24.90	11.92	19.70	16.78	35		3.80
1773	76.72	80.67	75.80	15.94	80.82	79.91	60.85	57.10	57.73	25.00	11.43	19.60	16.61	34.4		3.70
1785	75.80	79.76	76.11	15.94	79.46	78.54	59.45	55.69	56.79	25.00	11.41	19.50	16.61	34		3.70
1796	75.19	78.24	75.19	15.94	78.24	77.48	58.04	54.28	56.16	25.00	10.91	19.40	16.69	33.4	11.5	3.60
1809	74.20	77.70	75.27	16.02	76.94	76.18	56.55	52.93	55.45	24.90	10.89	19.20	16.69	32.9		3.60
1820	73.43	76.64	74.04	16.02	75.72	75.11	55.45	52.15	54.67	25.20	10.87	19.20	16.36	32.5		3.60
1831	72.66	75.88	73.58	16.02	74.50	74.20	54.35	51.20	54.35	25.50	9.82	19.10	16.36	32.2	11	3.40
1843	72.05	74.96	71.90	16.02	73.43	73.12	53.41	50.25	53.72	25.30	9.81	19.00	16.36	31.9		3.40
1854	71.44	74.20	71.13	16.02	72.36	72.05	52.46	48.99	52.93	25.50	9.79	19.00	16.36	31.6		3.40
1865	70.84	73.14	70.69	16.04	71.15	71.00	51.22	49.00	52.48	25.50	9.78	18.90	16.38	31.2	10.5	3.40
1878	70.23	72.07	70.23	16.04	70.07	70.07	50.43	47.89	52.01	25.50	9.76	18.70	16.38	31		3.40
1889	69.46	71.46	69.46	16.04	69.15	69.30	49.64	47.74	51.38	25.70	9.75	18.70	16.21	30.7		3.40
1900	68.69	70.69	68.38	16.04	68.23	68.38	49.00	46.15	50.90	26.30	9.74	18.60	16.21	30.5		3.40
1912	68.23	69.77	68.07	16.04	67.30	67.61	48.21	45.67	50.43	26.20	9.17	18.50	16.21	30.2		3.30
1923	67.61	68.69	66.85	16.06	66.08	66.55	47.28	44.41	49.97	25.80	9.16	18.50	16.23	30	10	3.30
1936	66.85	68.09	65.77	16.06	65.46	65.77	46.80	43.93	49.50	25.80	9.15	18.40	16.23	29.6		3.30
1947	66.39	67.32	65.00	16.06	64.38	65.00	46.01	42.50	49.18	26.10	8.55	18.40	16.23	29.4		3.20
1958	65.62	66.70	64.69	16.06	63.76	64.22	45.53	42.02	48.71	26.30	8.54	18.30	16.23	29.2		3.20
1977	64.38	65.15	63.14	16.06	62.36	62.98	44.41	40.90	48.23	25.90	8.52	18.30	16.23	28.9	9.75	3.20
1990	63.76	64.38	62.52	16.06	61.43	62.05	43.93	40.41	47.75	25.70	8.51	18.10	16.23	28.6		3.20
2001	63.14	64.07	61.74	16.06	60.65	61.43	43.30	39.61	47.44	25.60	8.50	18.10	16.23	28.5		3.20
2012	62.36	63.29	61.27	16.06	59.71	60.65	42.98	38.97	46.96	25.60	7.86	18.00	16.23	28.4		3.10
2024	61.74	62.67	60.81	16.06	59.09	60.03	42.34	38.49	46.64	25.50	7.85	18.00	16.23	28.1		3.10
2035	60.96	62.05	59.71	16.06	58.15	59.25	42.02	38.49	46.17	25.30	7.84	18.00	16.23	28	9.5	3.10
2046	60.54	61.01	59.29	16.12	57.42	58.67	41.42	37.25	46.05	25.70	7.84	17.90	16.28	27.9		3.10
2060	59.76	60.70	58.98	16.12	56.95	57.89	40.94	37.08	45.74	25.90	7.83	17.90	16.12	27.7		3.10
2071	59.14	60.07	58.67	16.12	56.16	57.26	40.62	36.76	45.26	26.40	7.82	17.80	16.12	27.5		3.10
2082	58.67	59.14	58.36	16.12	55.54	56.48	40.30	36.28	45.10	26.60	7.13	17.80	16.12	27.4		3.00
2094	58.04	58.67	57.42	16.12	54.75	55.85	39.98	35.96	44.78	26.90	7.80	17.80	16.12	27.3		3.10
2105	57.42	58.20	56.95	16.12	54.12	55.22	39.66	35.79	44.30	27.50	7.12	17.60	16.12	27	9	3.00
2119	56.63	57.57	56.48	16.12	53.65	54.59	39.18	35.47	44.14	27.50	7.11	17.60	16.12	27		3.00
2130	56.16	57.26	55.85	16.12	53.18	53.96	39.02	35.31	43.82	27.70	7.10	17.50	16.12	26.9		3.00
2141	55.69	56.63	55.22	16.12	52.71	53.49	38.70	34.66	43.50	27.00	7.10	17.50	16.12	26.7		3.00
2153	54.91	55.85	54.75	16.12	51.92	53.02	38.53	34.66	43.18	27.00	6.34	17.50	16.12	26.7		2.90

DAMPER FIELD TEST NO. 3:HEAT-UP COOL-DOWN WITH THERMAL DAMPER

2164	54.59	55.38	54.91	16.14	51.30	52.25	38.07	34.36	43.04	26.90	7.09	17.50	16.14	26.4	9	3.00
2177	53.83	54.77	54.61	16.14	50.99	51.78	37.91	34.20	42.56	27.30	6.33	17.40	16.14	26.3		2.90
2188	53.51	54.61	54.14	16.14	50.36	51.30	37.59	33.71	42.40	27.00	6.33	17.40	15.97	26.2		2.90
2199	52.88	54.14	53.51	16.14	50.04	50.99	37.27	33.55	42.24	27.00	6.32	17.40	15.97	26.2		2.90
2211	52.57	53.67	53.04	16.14	49.57	50.36	37.10	33.22	41.76	26.70	7.06	17.30	15.97	26.1		3.00
2222	52.09	53.20	52.88	16.14	49.25	49.72	36.78	32.90	41.76	26.70	6.31	17.30	15.64	25.8	8.5	2.90

DAMPER FIELD TEST NO. 4:HEAT-UP COOL-DOWN WITH THERMAL DAMPER:HOUSE PRESSURE:-6.5 Pa

Sheltair Scientific Ltd. Field Test Data April 1-2,1987

Taken from Phil Porter's house on W. 13th Ave., Vancouver

Legend:

t1: Post-mixing flue wall temperature, C (became unfixed from wall during test)
t2: Post-mixing flue gas temp, C
t3: Breech gas temp, C
t4: Reference temp, C
t5: Temp. of flue gas 10 cm beyond b. damper, 1 cm below top side of flue, C
t6: Flue gas temp 10 cm beyond b. damper, center of stream, C
t7: Flue wall temp 10 cm beyond b. damper, C
t8: Flue gas temp at thimble, C
t9: Flue wall temp at thimble, C (found not well fixed to wall after test)
t10: First dilution air temp, C *
t11: \
t12: Volumetric chimney flow, l/s (corrected for temperature variation)
t13: Chimney top wall temp, C
t14: Second dilution air temp, C *
t15: Chimney top gas temp, C
p16: Static pressure at chimney thimble, taken manually, Pa

* see attached notes for explanation

Configuration: Ameritherm barometric damper in vent connector.
House Pressure: -6.5 Pa; Outdoor Temperature: 9 C

Time (s)	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t12	t13	t14	t15	p16	Comments	flow press.
0	28.70	27.55	36.49	15.83	25.10	23.45	21.64	26.57	31.47	28.00	3.02	13.30	15.67	14.1	-1		2.60
13	27.88	26.90	36.49	15.83	24.93	23.45	21.47	26.08	31.31	28.10	0.00	13.30	15.83	13.9			2.50
24	27.23	26.24	36.17	15.83	24.77	23.95	21.47	25.26	31.31	28.50	-3.03	13.00	16.17	13.6			2.40
35	26.74	25.92	36.17	15.83	24.27	23.95	21.31	24.11	30.82	28.80	-3.03	12.90	16.5	13.4	-3		2.40
46	26.08	25.42	35.84	15.83	23.95	23.95	21.31	23.29	30.66	28.90	0.00	12.80	16.83	13.1			2.50

DAMPER FIELD TEST NO. 4:HEAT-UP COOL-DOWN WITH THERMAL DAMPER:HOUSE PRESSURE:-6.5 Pa

58	26.08	29.84	44.51	15.90	24.01	23.52	21.38	23.85	30.72	39.50	3.03	12.90	57.06	13	Burner on.	2.60
71	74.24	102.32	95.95	15.90	40.10	24.18	22.53	24.51	30.72	60.40	3.03	12.90	76.38	13		2.60
82	108.21	142.08	118.27	15.90	55.34	39.62	26.97	28.44	30.89	76.00	4.39	13.00	74.7	13.1		2.70
93	134.82	170.04	133.54	15.90	87.58	85.17	35.27	43.14	39.46	88.40	10.51	13.10	55.18	14.7	0	3.50
105	153.25	186.69	138.67	15.90	121.75	128.81	46.01	65.93	50.30	89.10	17.25	13.40	42.18	19	3.5	4.90
116	163.48	187.80	145.20	15.90	145.34	154.67	54.57	83.68	65.49	77.50	20.87	14.50	32.21	26.4	6.5	5.80
130	170.62	188.79	146.49	15.92	161.26	166.43	64.25	95.08	75.94	68.30	22.70	15.70	26.82	29.9	Fan on.	6.30
141	174.09	188.09	150.30	15.92	169.64	173.68	75.94	101.60	82.62	61.60	23.78	16.70	23.38	31.7	10	6.60
152	177.84	188.65	145.78	15.92	175.07	178.54	86.54	105.14	88.50	56.20	25.04	17.60	20.9	33.3		7.00
164	181.17	188.65	135.84	15.92	180.20	182.97	95.37	110.57	91.79	51.30	25.99	18.50	19.58	36.6	11.5	7.30
175	184.22	190.03	133.98	15.92	184.50	187.13	103.54	116.13	95.24	47.20	26.91	19.40	18.44	39.5		7.60
189	186.04	190.60	137.00	15.94	188.11	189.77	109.86	118.89	97.77	44.30	27.51	20.00	17.61	41.8		7.80
200	187.42	192.53	135.86	15.94	190.18	191.84	115.11	120.92	101.47	41.50	27.58	20.50	17.11	43.5		7.80
211	190.18	193.22	140.27	15.94	193.09	194.05	118.74	122.65	103.54	39.10	28.67	20.80	16.94	45.2	13.5	8.20
223	190.18	191.70	139.42	15.94	194.19	195.02	122.36	125.54	105.01	36.90	28.95	21.20	16.94	46.7		8.30
234	191.01	194.74	139.56	15.94	195.57	195.71	124.53	128.05	107.29	35.10	27.43	21.60	17.02	47.9	14	7.70
249	193.29	200.46	143.75	16.02	202.12	202.12	128.19	134.50	109.20	33.60	28.40	21.80	16.86	48.7		8.00
260	198.12	202.53	146.58	16.02	204.60	204.60	130.63	139.49	110.66	32.70	29.24	22.20	17.02	49.4		8.30
272	199.64	200.60	141.76	16.02	206.12	205.84	132.93	139.49	112.56	31.80	30.03	22.40	16.86	50.4	13	8.60
283	198.81	199.78	138.49	16.02	203.36	202.81	134.07	138.35	113.14	31.10	30.18	22.80	16.86	51.6		8.70
295	197.29	194.95	137.78	16.02	200.33	199.50	134.64	134.53	114.05	30.30	29.33	23.10	16.9	52.4	14.5	8.40
308	199.39	199.81	137.53	16.06	205.74	205.18	136.10	140.23	115.36	29.70	30.49	23.30	16.9	53		8.80
319	200.50	200.91	137.10	16.06	206.70	206.29	136.96	142.64	116.53	29.20	31.01	23.40	17.06	53.5		9.00
331	199.67	200.22	136.53	16.06	207.11	206.42	137.67	141.94	117.69	28.90	31.01	23.60	17.06	54	14.5	9.00
342	200.36	201.74	135.67	16.06	208.08	206.98	137.95	142.50	118.56	28.60	31.27	23.90	17.06	54.5		9.10
361	201.92	200.13	140.42	16.12	208.81	207.29	138.57	143.40	120.20	28.30	31.52	24.20	17.11	55.5	15	9.20
375	200.68	201.92	134.43	16.12	208.95	207.84	139.14	144.11	120.92	28.10	31.53	24.50	17.11	55.9		9.20
386	200.40	199.71	134.00	16.12	208.67	207.98	139.71	146.23	121.35	28.00	31.54	24.60	17.11	56.2	15	9.20
398	203.43	201.78	136.00	16.12	209.50	208.26	139.71	147.78	121.50	27.90	33.38	24.70	17.11	56.7		10.00
409	201.64	197.64	139.14	16.12	207.84	207.71	139.71	147.08	122.08	28.00	31.76	25.00	17.11	57		9.30
421	200.48	200.35	141.21	16.22	210.27	209.03	140.79	146.03	122.31	28.10	33.18	25.10	17.05	57.4	15.5	9.90
435	198.14	193.45	134.23	16.22	196.76	190.82	137.94	133.37	120.43	28.30	27.28	25.20	17.05	57.6	Burner off.	7.70
446	172.25	140.50	104.96	16.22	152.52	154.35	130.08	111.56	107.75	28.30	22.97	24.50	17.21	55.1	14.5	6.50
457	151.82	134.95	90.56	16.22	144.33	144.76	123.17	104.07	99.35	28.30	21.24	23.50	17.21	52.7		6.00
469	138.65	131.51	89.21	16.22	139.36	138.65	116.95	97.12	94.59	27.80	19.85	22.80	17.21	50.7		5.60

DAMPER FIELD TEST NO. 4:HEAT-UP COOL-DOWN WITH THERMAL DAMPER:HOUSE PRESSURE:-6.5 Pa

480	129.36	127.98	88.51	16.28	133.85	133.00	110.29	92.71	90.46	27.30	19.06	22.20	17.27	48.8	13	5.40
494	122.65	124.24	90.16	16.28	128.99	128.27	105.01	89.26	86.41	26.90	17.24	21.80	17.44	46.9		4.90
505	118.02	122.07	93.15	16.28	124.53	123.66	100.29	86.56	83.09	26.80	16.41	21.40	17.44	45.5		4.70
516	113.36	118.02	92.86	16.28	120.19	118.89	95.69	83.69	80.52	26.70	15.16	21.20	17.44	44		4.40
528	109.12	113.94	91.96	16.28	115.11	114.09	91.51	80.52	77.93	26.90	15.07	20.90	17.44	42.8		4.40
539	105.01	109.42	92.56	16.38	110.24	109.06	87.25	77.72	75.43	27.30	13.74	20.70	17.71	41.3	10	4.10
553	100.38	103.77	92.20	16.38	105.39	103.92	83.63	74.52	72.83	27.90	12.76	20.50	17.71	40		3.90
564	96.37	99.34	92.05	16.38	101.12	99.78	80.61	72.07	70.53	27.80	11.75	20.20	17.71	38.9		3.70
575	92.65	95.18	91.15	16.38	97.12	95.63	77.42	70.99	68.07	27.70	11.19	20.10	17.54	37.8	9 Fan off.	3.60
587	90.25	91.30	89.05	16.38	93.84	92.65	74.67	68.99	65.75	27.50	10.62	19.80	17.54	36.7	7	3.50
598	88.60	89.05	87.70	16.38	91.30	90.02	72.13	67.82	63.65	27.40	10.04	19.60	17.61	35.8	8	3.40
611	87.01	87.77	86.56	16.45	89.12	88.22	69.67	65.97	62.41	27.30	10.02	19.50	17.61	35		3.40
622	85.81	86.56	86.11	16.45	87.31	86.56	67.82	65.04	61.32	28.10	8.81	19.40	17.44	34.3		3.20
633	84.45	85.66	85.06	16.45	85.81	85.06	65.97	63.34	60.38	28.10	8.80	19.20	17.44	33.5		3.20
645	83.70	84.75	84.45	16.45	84.45	83.70	64.27	62.41	59.45	28.40	8.78	19.10	17.44	32.9		3.20
656	82.49	83.40	83.09	16.45	82.94	82.19	62.56	61.24	58.58	28.50	8.76	19.00	17.52	32.3	6.5	3.20
670	81.65	82.41	82.11	16.53	81.35	80.74	60.92	59.52	57.65	28.80	8.09	18.90	17.52	31.8		3.10
681	80.74	81.50	81.35	16.53	79.99	79.53	59.37	58.74	57.02	29.90	7.38	18.70	17.52	31.3		3.00
692	79.83	80.74	80.74	16.53	78.92	78.31	58.27	57.49	56.24	30.70	6.59	18.70	17.52	30.8		2.90
704	78.77	79.83	79.68	16.53	77.55	77.25	56.86	56.24	55.92	31.60	6.58	18.60	17.52	30.3	5	2.90
722	76.98	78.35	78.66	16.57	75.76	75.46	55.18	54.55	55.02	32.80	6.56	18.50	17.56	29.6		2.90
736	75.91	77.44	77.44	16.57	74.54	74.23	54.08	53.29	54.39	32.90	6.55	18.40	17.56	29.1		2.90
747	75.00	76.98	76.68	16.57	73.62	73.16	53.29	52.50	53.60	33.90	6.54	18.30	17.56	28.9	4.5	2.90
758	73.93	75.76	76.37	16.57	72.55	72.24	52.34	51.40	53.13	33.80	6.53	18.30	17.4	28.5		2.90
770	73.01	74.69	75.91	16.57	71.48	71.32	51.55	50.76	52.50	32.70	6.52	18.30	17.4	28.3		2.90
781	72.09	73.95	74.86	16.59	70.26	70.57	50.63	49.04	52.20	32.50	6.51	18.10	17.42	27.9	4.5	2.90
795	70.88	73.18	73.64	16.59	69.19	69.65	49.99	48.09	51.73	32.10	5.63	18.00	17.58	27.7		2.80
806	69.96	72.26	72.57	16.59	68.26	68.73	49.20	46.98	51.42	31.90	6.50	18.00	17.58	27.4		2.90
817	69.19	71.65	71.95	16.59	67.34	67.95	48.41	46.03	50.94	32.40	6.49	17.90	17.42	27.2		2.90
829	68.57	70.73	71.34	16.59	66.26	67.03	47.93	44.43	50.63	31.90	6.48	17.90	17.42	26.9		2.90
840	67.80	69.80	70.57	16.65	65.23	66.16	47.20	43.53	50.21	32.70	5.60	17.90	17.31	26.7	3.5	2.80
853	67.08	69.09	69.71	16.65	64.30	65.38	46.40	43.05	49.89	32.70	4.57	17.80	17.48	26.4		2.70
864	66.31	68.63	68.94	16.65	63.21	64.45	45.77	42.73	49.73	33.20	4.56	17.80	17.64	26.2		2.70
875	65.54	67.86	68.32	16.65	61.97	63.52	45.29	41.93	49.58	33.20	4.56	17.60	17.48	25.9		2.70
887	64.92	67.08	67.86	16.65	61.04	62.59	44.65	41.93	49.58	33.80	3.22	17.60	17.31	25.6		2.60

DAMPER FIELD TEST NO. 4:HEAT-UP COOL-DOWN WITH THERMAL DAMPER:HOUSE PRESSURE:-6.5 Pa

898	64.45	66.93	67.39	16.65	60.10	61.83	43.87	42.75	49.28	33.60	3.21	17.50	17	24.9	3	2.60
912	63.85	66.18	66.95	16.67	59.18	61.06	43.07	42.11	49.12	33.00	4.54	17.50	17	24.6		2.70
923	63.08	65.25	66.18	16.67	58.09	60.28	42.75	41.31	48.80	33.20	3.21	17.40	17	24.4		2.60
934	62.61	64.63	65.56	16.67	57.62	59.65	42.11	40.83	48.49	33.00	3.20	17.40	17	24.2	2.5	2.60
946	61.99	64.32	64.94	16.67	56.68	59.18	41.79	40.51	48.33	33.40	3.20	17.30	16.83	24		2.60
957	61.52	63.70	64.63	16.67	56.05	58.56	41.35	40.07	48.21	33.30	5.54	17.30	16.87	24	2.5	2.80
970	60.63	62.34	63.89	16.71	55.46	57.82	40.87	38.78	47.41	32.50	4.52	17.30	16.87	24.2		2.70
981	59.69	61.25	62.96	16.71	54.99	57.19	40.39	37.82	46.62	31.10	4.51	17.40	16.71	24.6		2.70
992	59.22	60.47	62.18	16.71	54.68	56.72	40.07	36.85	45.82	30.60	7.13	17.40	16.71	25		3.00
1004	58.13	59.22	61.09	16.71	54.37	56.09	39.59	36.04	45.03	29.60	7.13	17.40	16.71	25.6		3.00
1015	57.66	58.44	59.69	16.71	54.05	55.46	39.59	35.88	44.55	29.10	4.50	17.40	16.59	25.8		2.70
1028	56.76	58.33	58.80	16.59	53.31	54.57	39.31	35.93	43.96	29.00	7.11	17.30	16.59	25.7		3.00
1039	56.14	57.55	57.86	16.59	52.99	54.09	38.99	35.12	43.64	29.40	6.35	17.30	16.59	25.8		2.90
1050	55.67	56.61	57.08	16.59	52.36	53.47	38.67	34.80	43.16	29.00	3.17	17.30	16.75	25.9		2.60
1062	55.19	56.14	56.92	16.59	51.26	51.26	38.51	35.93	43.16	31.30	5.48	17.00	17.25	25		2.80
1080	54.57	56.29	56.91	16.75	50.30	51.09	37.86	36.41	43.63	31.60	3.16	16.80	17.08	23.9	1	2.60
1093	54.56	56.76	56.91	16.75	49.83	50.78	37.53	36.73	43.95	32.50	3.16	16.80	16.91	23.1		2.60
1104	54.40	56.76	56.91	16.75	49.20	50.30	37.05	37.70	44.11	32.50	3.16	16.70	16.75	22.5		2.60
1115	54.25	56.29	56.44	16.75	48.56	49.83	36.73	37.86	44.11	33.20	0.00	16.60	16.75	22	-1	2.50
1127	54.09	55.82	56.29	16.75	48.25	49.04	36.08	38.34	44.43	33.80	3.15	16.40	16.75	21.4		2.60
1138	53.77	55.19	55.97	16.75	48.09	47.95	35.78	38.52	44.45	34.50	0.00	16.40	16.6	20.7		2.50
1151	53.48	54.26	55.84	16.77	47.47	44.77	35.13	38.52	44.13	35.30	0.00	16.30	16.6	20.2		2.50
1162	52.85	52.85	55.52	16.77	45.56	42.05	34.65	38.20	44.13	37.80	0.00	16.10	16.6	19.6		2.50
1173	51.43	49.85	55.21	16.77	42.21	39.65	33.84	36.42	43.97	39.50	0.00	15.90	16.6	19		2.50
1185	49.06	46.52	54.74	16.77	39.65	37.88	33.19	34.65	43.33	40.50	-3.10	15.80	33.84	18.5		2.40
1196	56.46	53.64	80.05	16.77	37.55	36.10	32.54	32.38	42.69	57.40	3.09	15.70	68.12	17.9	-3 Burner on at 1200s.	2.60
1210	96.42	123.51	118.59	16.77	56.46	57.87	35.29	36.42	43.01	75.40	6.39	15.70	60.68	18		2.90
1221	129.12	170.48	135.99	16.77	99.24	107.50	42.85	57.72	51.74	86.10	13.71	15.90	46.68	20.1		4.10
1232	150.31	187.00	144.09	16.77	135.13	143.95	51.59	81.57	63.95	80.00	18.98	16.70	36.42	26.3		5.30
1244	162.53	190.73	146.92	16.77	156.22	161.97	62.08	92.55	76.55	70.60	21.68	17.80	28.8	30.7	7	6.00
1255	171.74	191.83	149.18	16.77	167.84	172.15	74.11	100.13	86.40	63.30	23.44	19.00	24.21	33	10 Fan on	6.50
1269	177.85	189.21	145.23	16.77	175.91	179.38	86.85	106.91	92.70	57.20	25.34	20.10	21.74	35.7		7.10
1280	181.87	187.83	145.51	16.77	180.21	183.26	96.13	111.89	96.72	52.80	25.73	20.90	20.25	39.1		7.20
1291	183.67	187.69	133.99	16.77	183.67	185.89	103.82	115.25	100.58	48.90	27.14	21.60	19.26	41.9	12	7.70
1303	185.06	189.76	129.41	16.77	186.58	187.96	109.70	117.14	103.38	46.10	27.72	22.00	18.59	44.1		7.90

DAMPER FIELD TEST NO. 4:HEAT-UP COOL-DOWN WITH THERMAL DAMPER:HOUSE PRESSURE:-6.5 Pa

1314	187.27	191.56	128.40	16.77	188.79	189.76	114.52	120.76	105.89	43.50	28.03	22.40	18.15	46.2	13.5		8.00
1328	189.40	188.70	126.87	16.83	191.61	192.02	119.22	124.28	108.43	41.30	28.85	22.90	17.82	47.9			8.30
1339	190.50	191.74	126.87	16.83	192.85	193.40	122.55	125.29	110.78	39.60	29.14	23.30	17.82	49.3			8.40
1351	191.33	191.33	131.47	16.83	194.09	194.23	125.00	128.02	111.65	37.90	29.66	23.60	17.66	50.4	14.5		8.60
1362	191.05	191.74	131.90	16.83	195.89	195.75	127.16	129.75	113.84	36.40	29.95	24.00	17.66	51.5			8.70
1374	191.05	193.82	134.61	16.83	196.44	196.44	128.74	130.75	114.43	35.20	29.97	24.20	17.66	52.3			8.70
1385	192.07	192.62	139.08	16.89	198.01	197.45	129.94	132.09	115.93	34.30	30.25	24.50	17.55	53.3	15		8.80
1399	191.38	192.49	143.49	16.89	198.83	198.28	131.09	133.09	117.10	33.40	30.99	24.70	17.55	54.1			9.10
1410	191.10	191.79	144.48	16.89	198.70	198.28	132.09	133.52	117.97	32.70	30.99	25.00	17.55	55			9.10
1422	191.79	193.31	141.78	16.89	199.39	198.97	132.66	134.09	118.40	31.90	31.24	25.10	17.55	55.5			9.20
1440	192.62	193.87	141.07	16.89	200.35	200.35	133.99	137.55	119.60	31.10	31.52	25.50	17.59	56.5	15.5		9.30
1453	192.66	192.66	135.41	16.93	201.21	200.25	134.41	136.41	121.05	30.60	31.52	25.70	17.59	57			9.30
1464	194.45	195.69	133.13	16.93	201.21	200.52	135.13	137.55	121.05	30.20	31.76	25.90	17.59	57.3			9.40
1476	194.45	193.90	127.54	16.93	202.04	200.52	135.56	136.84	121.77	29.90	31.99	26.10	17.59	57.7			9.50
1487	195.00	193.62	125.95	16.93	201.76	200.80	135.98	137.55	122.06	29.60	32.00	26.20	17.59	57.9			9.50
1499	194.87	195.42	128.54	16.93	202.45	201.90	136.27	139.12	123.39	29.40	32.26	26.30	17.63	58.4	16.5		9.60
1512	193.66	194.90	130.01	16.97	203.45	202.48	136.45	140.01	123.83	29.00	32.28	26.60	17.63	58.8			9.60
1523	193.93	194.90	130.87	16.97	204.00	202.90	137.02	141.14	123.68	28.90	32.52	26.70	17.63	59.2			9.70
1535	194.21	194.90	129.58	16.97	204.69	203.86	137.16	142.42	124.11	28.80	33.88	26.80	17.63	59.5			10.30
1546	193.93	190.89	123.68	16.97	201.24	200.42	136.73	138.01	124.84	28.50	33.11	26.90	17.8	59.9			10.00
1558	194.35	187.44	116.15	16.97	200.14	200.83	136.73	138.58	124.98	28.30	32.00	27.20	17.86	60			9.50
1571	195.22	190.94	126.47	17.03	184.86	181.26	135.78	127.62	121.86	28.10	24.84	27.00	17.69	59.5			6.90
1582	169.03	145.87	98.59	17.03	154.76	155.32	128.63	112.27	109.93	28.00	21.20	26.10	17.86	56.7		Burner off.	5.90
1594	151.10	140.34	91.74	17.03	147.57	147.14	122.15	104.20	103.17	27.70	20.37	25.20	18.02	54.3	14		5.70
1605	139.63	137.07	91.14	17.03	142.33	141.19	116.06	99.48	98.59	27.40	19.26	24.60	18.02	52.3	13		5.40
1616	131.64	132.78	92.63	17.03	136.78	135.64	110.95	95.32	95.17	27.20	17.76	24.10	18.11	50.5	11.5		5.00
1628	124.53	128.71	94.65	17.12	131.29	130.14	105.31	91.07	91.82	27.00	17.28	23.60	18.11	48.8			4.90
1642	118.89	123.38	96.74	17.12	125.54	124.53	100.15	87.62	88.82	27.00	16.05	23.30	18.11	47.2			4.60
1653	113.52	117.30	96.29	17.12	120.49	119.33	95.99	85.06	85.36	27.00	15.17	23.10	18.11	45.8	10.5		4.40
1664	108.69	113.81	97.03	17.12	115.70	114.24	91.97	82.04	82.34	27.50	14.25	22.90	18.11	44.6			4.20
1676	104.43	108.98	95.84	17.12	110.89	109.42	88.07	79.61	79.61	28.40	12.86	22.70	18.11	43.4			3.90
1687	100.48	104.91	93.94	17.16	105.79	104.47	84.04	76.91	76.91	29.20	12.77	22.40	18.15	42.1			3.90
1701	96.33	99.74	94.39	17.16	101.37	100.04	80.56	73.71	74.47	29.70	11.75	22.20	18.15	40.8			3.70
1712	92.60	95.43	92.75	17.16	97.52	95.88	77.67	71.71	72.17	29.60	11.69	21.90	18.15	39.9	9		3.70
1723	89.01	90.66	88.41	17.16	93.35	91.85	74.47	69.25	69.72	29.10	10.61	21.80	18.15	39			3.50

DAMPER FIELD TEST NO. 4:HEAT-UP COOL-DOWN WITH THERMAL DAMPER:HOUSE PRESSURE:-6.5 Pa

1735	86.45	87.81	85.25	17.16	90.36	89.01	71.71	66.94	67.40	28.50	10.03	21.70	18.15	38.2			3.40
1746	84.65	86.36	83.94	17.22	88.16	87.11	69.31	65.45	65.76	28.10	10.00	21.40	18.21	37.3			3.40
1759	83.04	85.45	82.43	17.22	86.36	85.45	67.00	64.06	64.37	27.70	9.98	21.30	18.21	36.6			3.40
1770	81.83	84.10	81.83	17.22	84.70	83.79	64.99	62.81	63.44	27.40	8.78	21.20	18.21	36	8.5		3.20
1781	80.92	83.04	81.07	17.22	83.19	82.43	63.28	62.04	62.35	27.30	8.76	21.10	18.21	35.5			3.20
1800	79.71	81.53	79.71	17.22	81.07	80.46	60.79	60.17	61.42	27.50	8.09	20.90	18.25	34.5	8		3.10
1813	78.83	80.65	78.83	17.26	79.74	78.98	59.11	59.27	60.67	27.30	8.07	20.80	18.09	34			3.10
1824	78.07	79.74	78.22	17.26	78.68	77.92	58.02	57.71	59.89	27.70	8.06	20.70	18.09	33.6		Missed fan off time.	3.10
1835	77.16	78.68	77.61	17.26	77.31	76.85	56.61	56.61	59.11	27.80	7.35	20.70	17.92	33.4			3.00
1847	76.39	77.92	77.16	17.26	76.09	75.63	55.67	55.98	58.49	27.80	8.04	20.60	17.59	33			3.10
1858	75.48	76.85	76.39	17.26	74.87	74.56	54.73	54.89	58.02	27.80	8.02	20.50	17.61	32.7	7.5		3.10
1870	74.89	75.96	75.65	17.28	73.82	73.66	53.80	53.96	57.41	28.40	6.54	20.50	17.44	32.3			2.90
1883	73.97	74.89	75.19	17.28	72.74	72.59	52.86	52.39	56.79	28.50	7.30	20.30	17.44	32.1			3.00
1894	73.20	73.97	74.28	17.28	71.52	71.52	52.07	51.44	56.32	28.80	5.65	20.20	17.44	31.7			2.80
1905	72.28	73.51	73.66	17.28	70.60	70.90	51.12	50.81	56.00	28.80	5.64	20.20	17.44	31.2			2.80
1917	71.52	73.05	73.20	17.28	69.67	70.13	50.33	49.86	55.53	29.60	5.64	20.10	17.28	30.8			2.80
1928	70.90	72.28	72.59	17.28	68.60	69.21	49.54	47.96	55.06	29.40	4.60	20.00	17.44	30.5			2.70
1942	69.83	71.52	71.52	17.28	67.52	68.13	48.75	47.32	54.59	30.00	5.62	20.00	17.44	30.1			2.80
1953	68.90	70.60	70.90	17.28	66.74	67.52	48.12	46.21	54.28	30.20	4.58	19.80	17.44	29.9	5.5		2.70
1964	68.13	70.13	70.29	17.28	65.51	66.74	47.32	45.26	53.96	30.70	4.58	19.80	17.44	29.6			2.70
1976	67.21	69.21	69.52	17.28	64.89	65.97	46.85	44.62	53.80	31.80	4.57	19.70	17.44	29.5			2.70
1987	66.74	68.42	68.73	17.26	63.63	65.02	46.03	44.12	53.31	31.80	4.57	19.70	17.42	29.2			2.70
2000	65.80	67.81	67.96	17.26	62.85	64.25	45.40	42.84	53.16	32.10	4.56	19.70	17.42	29			2.70
2011	65.02	67.19	67.03	17.26	62.08	63.47	44.92	42.68	52.84	32.20	4.56	19.60	17.42	28.9	5		2.70
2022	64.40	66.57	66.57	17.26	61.45	62.70	44.44	42.04	52.37	32.30	4.55	19.60	17.42	28.6			2.70
2034	63.78	65.80	65.80	17.26	60.36	61.92	43.80	41.56	52.05	32.90	4.55	19.50	17.42	28.4			2.70
2045	63.32	65.33	65.33	17.26	59.48	61.20	43.38	40.82	51.64	32.30	4.54	19.50	17.48	28.3			2.70
2058	62.60	64.61	64.30	17.32	58.70	60.42	42.90	40.66	51.48	31.40	3.21	19.50	17.98	28			2.60
2069	61.98	63.84	63.68	17.32	58.23	60.11	42.42	40.18	51.16	31.00	3.21	19.50	17.98	27.9			2.60
2080	61.20	63.37	63.22	17.32	57.45	59.33	42.10	40.02	50.85	30.50	3.20	19.40	17.98	27.8			2.60
2092	60.89	62.91	62.60	17.32	56.82	58.55	41.78	39.70	50.53	30.30	3.20	19.20	18.15	27.7			2.60
2103	60.11	62.44	62.44	17.32	55.88	58.08	41.46	39.17	50.33	30.10	3.20	19.20	17.61	27.4	4.5		2.60
2117	59.45	61.63	61.94	17.28	55.06	57.26	40.94	39.01	49.86	30.30	3.19	19.20	17.94	27.3			2.60
2128	59.13	61.47	61.63	17.28	54.75	56.63	40.62	38.85	49.54	29.70	3.19	19.10	17.94	27			2.60
2139	58.51	61.00	61.16	17.28	54.12	56.00	40.14	38.85	49.07	29.40	3.19	19.10	17.61	26.9			2.60

DAMPER FIELD TEST NO. 4:HEAT-UP COOL-DOWN WITH THERMAL DAMPER:HOUSE PRESSURE:-6.5 Pa

2158	58.04	59.91	59.91	17.28	53.65	55.06	39.66	38.69	48.59	29.70	0.00	19.10	17.61	26.8	4	2.50
2169	57.26	59.13	59.29	17.28	53.02	54.59	39.17	38.37	48.12	29.90	-3.18	19.10	17.61	26.6		2.40
2183	56.79	58.51	58.35	17.28	52.39	53.96	39.01	38.21	47.80	30.00	-3.18	19.00	17.44	26.4		2.40
2194	56.32	58.20	57.57	17.28	52.07	53.33	38.69	37.89	47.64	29.60	0.00	19.00	17.44	26.3	4	2.50
2205	55.85	57.73	57.26	17.28	51.44	53.02	38.37	37.57	47.32	30.00	-15.54	18.90	17.44	26.2		0.10
2217	55.22	56.94	56.63	17.28	51.28	52.39	38.05	37.40	47.16	30.30	-15.85	18.90	17.61	26.2		0.00

DAMPER FIELD TEST NO. 5:THERMAL DAMPER INSTALLED WITH 8 Pa HOUSE PRESSURE

Sheltair Scientific Ltd. Field Test Data April 1-2,1987

Taken from Phil Porter's house on W. 13th Ave., Vancouver

Legend:

t1: Post-mixing flue wall temperature, C (became unfixed from wall during test)
t2: Post-mixing flue gas temp, C
t3: Breech gas temp, C
t4: Reference temp, C
t5: Temp. of flue gas 10 cm beyond b. damper, 1 cm below top side of flue, C
t6: Flue gas temp 10 cm beyond b. damper, center of stream, C
t7: Flue wall temp 10 cm beyond b. damper, C
t8: Flue gas temp at thimble, C
t9: Flue wall temp at thimble, C (found not well fixed to wall after test)
t10: First dilution air temp, C *
t11: \
t12: Volumetric chimney flow, l/s (corrected for temperature variation)
t13: Chimney top wall temp, C
t14: Second dilution air temp, C *
t15: Chimney top gas temp, C
p16: Static pressure at chimney thimble, taken manually, Pa

* see attached notes for explanation

Configuration: Ameritherm barometric damper in vent connector.
House Pressure: -8 Pa; Outdoor Temperature: 10 C

Time (s)	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t12	t13	t14	t15	p16	Comments	flow pres
1	30.03	26.27	52.94	17.36	24.13	24.46	22.98	21.33	38.93	37.40	-5.25	13.6	20.84	12.3	-5	Backdrafting	2.20
14	30.19	26.27	52.94	17.36	24.13	24.46	22.98	21.83	39.09	37.90	-5.25	13.7	20.34	12.4	-5		2.20
25	30.19	26.27	52.46	17.36	24.46	24.46	22.82	21.83	39.09	38.00	-5.25	13.6	20.51	12.4			2.20
36	30.19	26.27	52.30	17.36	24.13	24.46	22.82	21.83	38.93	38.20	-5.25	13.6	19.51	12.5			2.20
47	30.35	26.27	52.30	17.36	24.46	24.46	22.82	21.99	38.93	37.80	-4.29	13.6	19.18	12.5	-5		2.30

DAMPER FIELD TEST NO. 5:THERMAL DAMPER INSTALLED WITH 8 Pa HOUSE PRESSURE

58	30.52	26.43	52.46	17.34	24.44	24.44	22.63	22.30	39.07	37.90	-4.29	13.6	43.40	12.8	pegged	Burner on, spillage	2.30
73	31.64	39.88	164.41	17.34	24.44	24.44	22.80	21.64	38.91	55.60	-5.25	13.5	66.03	12.6	"		2.20
84	34.56	49.76	197.14	17.34	24.11	24.44	23.13	20.98	38.43	66.50	-5.25	13.3	79.51	12.4	"		2.20
95	49.44	60.75	212.85	17.34	24.11	24.44	23.62	20.32	38.27	77.30	-5.25	13.1	82.09	12.5	"		2.20
107	76.47	82.85	222.63	17.34	24.11	24.44	24.11	20.49	38.11	87.70	-5.25	13.1	89.02	12.6	"		2.20
118	95.60	98.27	233.95	17.34	24.46	24.46	25.45	20.51	37.96	96.30	-5.25	13	93.97	12.6	"	Fan on.	2.20
132	97.69	79.99	245.17	17.36	24.46	24.46	26.76	20.17	37.64	102.20	-5.25	13	93.83	12.6	"		2.20
143	98.29	74.65	254.76	17.36	24.63	24.46	28.07	20.17	37.48	107.60	-5.25	12.9	98.58	12.6	"		2.20
154	98.88	89.19	262.15	17.36	25.28	24.63	29.37	20.34	37.32	113.20	-5.25	12.9	103.02	12.9	"		2.20
166	115.91	115.62	265.09	17.36	26.43	24.79	30.35	21.00	37.48	121.80	-4.29	13	93.97	13	"		2.30
177	134.36	132.07	267.90	17.36	27.58	24.98	32.00	21.68	37.66	130.30	-4.29	13	89.96	13.1	"	Ameritherm does not open, continuous spillage for entire run.	2.30

DAMPER FIELD TEST NO. 6:NO THERMAL DAMPER INSTALLED WITH 8 Pa HOUSE PRESSURE

Sheltair Scientific Ltd. Field Test Data April 1-2,1987

Taken from Phil Porter's house on W. 13th Ave., Vancouver

Legend:

t1: Post-mixing flue wall temperature, C (became unfixed from wall during test)
t2: Post-mixing flue gas temp, C
t3: Breech gas temp, C
t4: Reference temp, C
t5: Temp. of flue gas 10 cm beyond b. damper, 1 cm below top side of flue, C
t6: Flue gas temp 10 cm beyond b. damper, center of stream, C
t7: Flue wall temp 10 cm beyond b. damper, C
t8: Flue gas temp at thimble, C
t9: Flue wall temp at thimble, C (found not well fixed to wall after test)
t10: First dilution air temp, C *
t11: \
t12: Volumetric chimney flow, l/s (corrected for temperature variation)
t13: Chimney top wall temp, C
t14: Second dilution air temp, C *
t15: Chimney top gas temp, C
p16: Static pressure at chimney thimble, taken manually, Pa

* see attached notes for explanation

Configuration: No barometric damper in vent connector. Sleeve inserted instead.
House Pressure: -8 Pa; Outdoor Temperature: 10 C

Time (s)	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t12	t13	t14	t15	p16	Comments	flow press.
0	24.94	22.80	49.76	17.51	20.32	20.49	19.99	18.17	30.01	29.10	-13.12	11.90	32.13	13.1		Backdrafting	0.6
13	25.10	22.97	49.60	17.51	20.49	20.49	20.16	18.34	30.01	29.40	-13.79	11.90	31.96	13.1			0.4
24	25.10	23.13	49.29	17.51	20.32	20.49	19.99	18.17	29.69	29.50	-10.85	11.90	31.96	13.1			1.2
35	25.10	22.97	49.13	17.51	20.49	20.49	19.99	18.34	29.69	29.60	-9.98	11.90	32.13	13			1.4
46	25.10	22.97	48.97	17.51	20.49	20.66	19.99	18.34	29.69	29.90	-9.99	11.90	32.29	13			1.4

DAMPER FIELD TEST NO. 6:NO THERMAL DAMPER INSTALLED WITH 8 Pa HOUSE PRESSURE

58	25.43	23.13	48.97	17.51	20.49	20.66	19.99	18.17	29.69	29.90	-8.52	11.90	45.16	12.9	Burner on, spillage	1.7
71	25.60	22.80	170.27	17.51	20.49	20.66	20.16	18.17	29.69	35.30	-7.37	11.90	61.84	12.9		1.9
82	29.36	28.87	209.68	17.51	20.49	20.66	20.32	18.34	29.69	41.10	-6.73	11.90	83.3	12.9		2
93	34.88	47.86	225.26	17.51	20.66	20.99	20.49	18.50	30.01	46.90	-7.38	11.90	86.62	13		1.9
105	40.04	42.28	233.40	17.51	20.99	21.15	20.66	18.50	30.01	51.70	-7.97	11.90	92.92	13.1		1.8
116	43.72	34.88	245.30	17.51	21.15	21.10	20.94	18.45	29.96	55.90	-7.38	11.90	91.38	13.4		1.9
130	47.34	35.97	252.75	17.46	21.27	21.27	21.27	18.45	29.96	60.00	-7.38	12.00	97.33999	13.5	Fan on.	1.9
141	50.66	37.74	261.96	17.46	21.43	21.27	22.09	18.45	29.64	64.00	-7.38	11.90	101.34	13.5		1.9
152	54.13	38.38	267.84	17.46	21.76	21.27	22.92	18.45	29.64	68.20	-7.38	11.90	112.06	13.5		1.9
164	57.90	50.51	273.46	17.46	22.09	21.43	23.90	18.45	29.64	76.00	-6.74	11.9	118.61	13.5		2.00
175	62.57	71.22	276.42	17.46	22.75	21.76	24.94	18.50	29.69	82.30	-7.39	11.9	121.55	13.5		1.90
188	66.80	55.44	283.26	17.51	22.97	21.81	25.92	18.50	29.69	84.80	-7.39	11.9	125.74	13.5	for entire run.	1.90
199	69.89	53.24	288.31	17.51	23.13	21.98	27.07	18.50	29.52	87.70	-8.53	11.9	132.2	13.5	Continuous spillage.	1.70