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RESIDENTIAL COMBUSTION VENTING FAILURE
A SYSTEMS APPROACH

FINAL TECHNICAL REPORT

PROJECT 5
REMEDIAL MEASURES FOR OIL-FIRED APPLIANCES

Prepared for:

The Research Division

Policy Development and Research Sector

Canada Mortgage and Housing Corporation

Prepared by:

Scanada Consultants Limited

Scanada Sheltair Consortium

July 27, 1987

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July 27, 1987

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EXECUTIVE SUMMARY

A research project was conducted to find and evaluate remedial measures for combustion venting problems with oil-fired appliances. It was hoped to find measures that held promise for near- to mid-term commercialization. The project was one of three projects conducted by a multi-disciplinary team of scientists and engineers to investigate combustion venting remedial measures for several types of combustion appliances. The research represents one sub-project in an overall project to investigate residential combustion venting failure.

Three remedial measures for oil-fired appliances were evaluated and were found to hold varying degrees of promise for near- to mid-term commercialization. The measures evaluated were the solenoid delay valve, the draft inducing fan and a comprehensive retrofit package consisting of a sealed insulated flue liner, a sealed flue pipe (with no barometric damper) and a high pressure burner. No attempts were made to evaluate issues such as long term durability, or compliancies with codes and standards.

INTRODUCTION

This report describes one of seven sub-projects of an overall project entitled -

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH

- which was carried out for Canada Mortgage and Housing Corporation by the Scanada Sheltair Consortium Inc. A summary of the overall project is provided in Appendix A.

This is one of several final reports on the fifth sub-project, "Remedial Measures", which was concerned with research on remedial measures for various types of combustion equipment experiencing combustion venting problems. This report deals with remedial measures for oil-fired appliances.

This phase of the project was designed to focus on those remedial measures that promised to be simple, cost-effective and widely applicable to houses experiencing typical combustion venting failures. In order to identify measures meeting these criteria, a review of available measures was undertaken. This review and its results are described in Appendix B, which also provides the rationale for choosing the three measures which were finally included in this research.

SUMMARY OF RESULTS

The research on remedial measures for oil-fired appliances was conducted by Solsearch Inc. of Charlottetown, P.E.I. under subcontract to the Scanada Sheltair Consortium. Solsearch's detailed reports are appended as follows:

Appendix B	-	an early progress report providing the rationale for Solsearch's choice of measures to investigate
Appendix C	-	Solsearch final report

The results reported in the final report are summarized here.

The combustion venting system of an oil furnace is significantly more complex than that of a gas furnace due to the presence of the burner blower and the barometric damper. The blower pressurizes the combustion chamber flue pipe and portions of the flue, thus helping to resist backdrafting but perhaps exacerbating any tendency to spillage. The barometric damper adds higher friction losses to dilution flow than is the case for a gas furnace dilution port but it also provides very strong resistance to spillage flow because it closes and presents very little flow area.

This complexity created problems in the research, resulting in several abortive, exploratory tests in addition to those that produced more tangible output.

Flue Pipe Flow

A very instructive test performed by Solsearch was designed to determine the effect of house depressurization on direction of flow in the flue pipe. This was accomplished by inserting an air flow meter in the flue pipe, approximately 1 m downstream from the furnace breaching, and recording flow while gradually depressurizing the room with a blower door. The burner fan was operating but there was no oil flow and hence no firing. The test was performed on a conventional oil burner (Aero Environmental Model FAFC), with a 1.25 USGPH nozzle and barometric damper, set up in the laboratory of Holland College in Charlottetown. The results are shown in Figure 1.

The point to note in Figure 1 is that, even without the buoyancy created by a firing burner, flow in the flue was positive (up the chimney) until the house was depressurized to 65 Pa. The significance of this is that we need not be concerned about **backdrafting** with oil furnaces. The burner fan is able to develop sufficient pressure (and the barometric damper closes and thus does not release that pressure) to overcome any level of depressurization likely to be encountered in a house.

Thus we need only be concerned about **spillage** of combustion gases due to an imbalance between the rate of flow through the furnace and the rate of flow up the chimney. When the rate of flow through the furnace exceeds the rate of flow in the chimney, even when the latter is upward, the flue pipe and portions of the flue will be pressurized and flue gases will be spilled into the furnace room through leaks around the barometric damper, along the flue pipe and at the flue pipe's connections to the furnace and the chimney. Such a condition is most likely to occur at furnace start-up, when the chimney is cold, and will continue until hot gases are introduced into the vertical portions of the venting system so that their buoyancy can accelerate flue flow to eventually match the furnace flow.

Solsearch looked at three remedial measures for oil furnaces subject to pressure-induced spillage:

- the solenoid oil flow delay valve,
- the retrofit draft-inducing fan, and
- elimination of the barometric damper combined with a high pressure burner and insulated chimney.

Solenoid Delay Valve

A delayed action solenoid valve allows the fan on the oil burner to activate before the oil flow is started. The fan pressurizes the combustion chamber and at least the base of the chimney. The laboratory tests conducted by Solsearch confirmed that this initial pressurization will reverse a backdrafting chimney before the burner fires and combustion products are created. However, because the flue pipe is pressurized, there can still be spillage from the unintentional or intentional holes (e.g. barometric damper perimeter). Thorough sealing of the flue pipe and all connections will reduce this spillage. Also, since proper flow

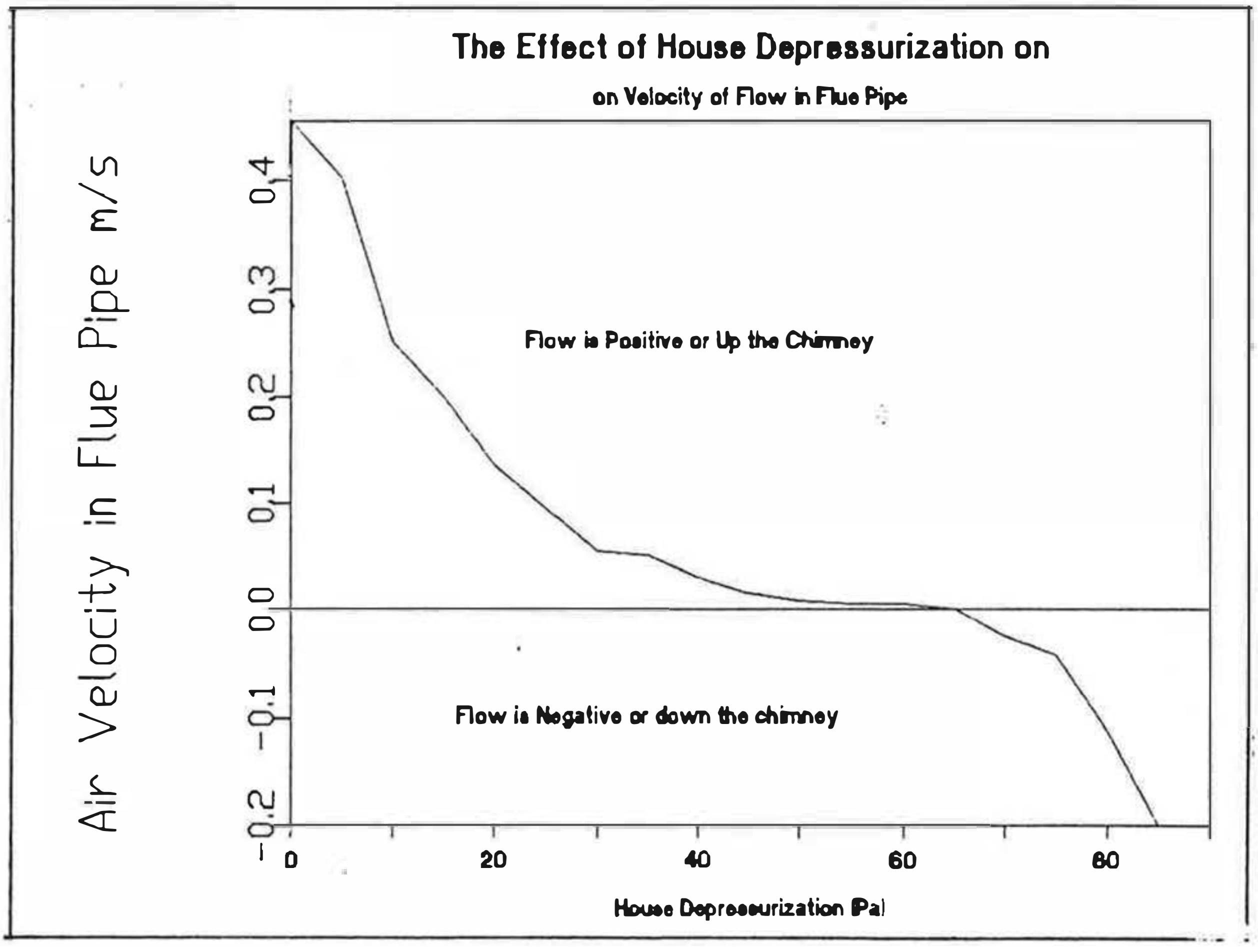


FIGURE 1: Effect of Depressurization on Flue Pipe Flows

in the chimney is established sooner relative to the burner's first firing, the duration of spillage of combustion products may be reduced; however, no measurements of the effects of this remedial measure on spillage duration were undertaken during these tests.

Draft-Inducing Fan

The induced draft fan, mounted on the flue pipe, draws the products of combustion out of the combustion chamber and then pushes this flow up the chimney. Because the induced draft and burner fans create different pressure regimes in the furnace-flue pipe-chimney system, they were tested both separately and together at the Holland College Energy Systems Technology Laboratory.

The results of these tests showed that the induced draft fan, especially if used in conjunction with a solenoid delay on the burner, can reverse backdrafts and minimize spillage under any likely house depressurization. Downstream of the fan there may be some start-up spillage at flue pipe joints, unless these are properly sealed. The key advantage of the induced draft fan over other oil remedial measures is that it depressurizes the flue pipe upstream of the device, thereby eliminating spillage through the barometric damper, flue pipe leaks and breech connection leaks. However, this device may also depressurize the combustion chamber possibly altering flame patterns. There was no investigation of the effect of the fan on furnace/boiler burner performance.

Elimination of Barometric Damper

The "high pressure burner/insulated flue combination" recommended by ESSO Canada was evaluated in this project. This retrofit system consists of three elements:

- replacement of the existing oil burner with a high pressure burner
- sealing of the flue pipe, including elimination of the barometric damper
- installation of a seamless, insulated flue liner in the existing masonry chimney, complete with wind-diverting cap

To test the improvement of draft due to this system, two houses were retrofitted with it. Tests before and after the installations showed a 4 to 7 Pa improvement in draft. The possible reduction in condensation due to the chimney insulation was not investigated.

The system does create improved chimney draft and results in fewer holes at which flue gas spillage can occur. The margin of improvement is not as great as with the induced draft fan and the cost of this retrofit is quite high. However, it may be a good option for homeowners with a furnace/boiler in good condition and a chimney in need of repair (e.g suffering from condensation problems). In many cases it may also provide energy savings due to improved efficiency and thus the cost can be offset against this benefit as well as its benefit to combustion venting.

APPENDIX A

OVERALL PROJECT SUMMARY

OVERALL PROJECT SUMMARY

The project reported on here was designed to expand on previous studies of the problem of incomplete venting of combustion products from heating appliances in order to approach a more nearly comprehensive understanding of the extent and nature of the problem in the Canadian housing stock. This project, which was carried out for Canada Mortgage and Housing Corporation by the Scanada Sheltair Consortium Inc., consisted of the seven sub-projects described below.

PROJECT 1 COUNTRY-WIDE SURVEY

Spillage detectors were installed on the draft hoods or barometric dampers of gas and oil furnaces and water heaters in 937 houses spread throughout the Vancouver, Winnipeg, Toronto, Ottawa and Charlottetown regions. The detectors were left in place for approximately 2 months in late winter.

Of the gas heated houses surveyed, 10% had experienced prolonged and unusual amounts of combustion gas spillage and 65% had experienced either short duration start-up spillage or prolonged spillage of small amounts of combustion gas. Of the oil heated houses, 55% had experienced significant spillage of high temperature combustion gas, but some of these spillage events may have been of only short duration.

Preliminary analysis indicates that spillage problems seem to be related to the following house or heating system characteristics:

- Winnipeg houses (believed to be more nearly airtight due to extensive use of stucco)
- pre-1945 houses
- post-1975 houses
- one storey houses
- exterior chimneys
- masonry chimneys with under-sized metal liners
- houses with three or more exhaust fans
- houses with two open masonry fireplaces
- poorly maintained heating appliances

PROJECT 2 MODIFICATIONS AND REFINEMENTS TO THE FLUE SIMULATOR MODEL

FLUE SIMULATOR, a detailed theoretical computer-based model of the combustion venting process had been developed for CMHC prior to this project. It is intended for use as an aid in understanding the mechanisms of combustion venting failure and the circumstances that give rise to them. The modifications undertaken in this project were intended to make the program easier to use and to allow it to model a wider variety of furnace/flue/house systems. The modifications included -

- refinements to algorithms
- more efficient operation of the program
- modelling additional features and system types
- user-friendly input and output

The modified model was validated against field test data and used to investigate a number of issues.

A separate developmental version of the program, called WOOD BURNING SIMULATOR, was successfully developed to model the combustion and combustion venting process in wood stoves and fireplaces.

PROJECT 3 REFINEMENT OF THE CHECKLISTS

A procedure for identifying and diagnosing combustion venting failures had previously been developed for CMHC - the Residential Combustion Safety Checklist. This project provided an opportunity to refine the checklist and develop variations of it suitable for a variety of possible users such as furnace service personnel, air sealing contractors, homeowners, etc. Early in the project, it was decided to separate the identification procedures from the diagnostic procedures. This allowed the process of identifying houses with potential for combustion venting problems to remain relative simple and allowed the diagnostic process to become more complex since it would only be used on houses where the extra effort would likely be worthwhile. Thus the original backdraft checklist has grown into five separate tests/procedures -

Venting Systems Pre-test
- a quick, visual inspection procedure which identifies a house as either unlikely to experience pressure-induced spillage or requiring further investigation

Venting Systems Test
- a detailed test procedure for determining to what extent the combustion venting system of a house is affected by the envelope airtightness and operation of exhaust equipment, perhaps the clearest descendent of the old backdraft check-list.

Chimney Performance Test
- a simple method of determining whether a chimney is capable of providing adequate draft

Heat Exchanger Leakage Test
- a quick method of determining if the heat exchanger of a furnace has a major leak

Chimney Safety Inspection
- a visual check for maintenance problems in the chimney system

These tests/procedures are all presented in a manual entitled "Chimney Safety Tests". Full trials of the procedures were carried out on the case study houses investigated in Project 6.

PROJECT 4 HAZARD ASSESSMENT

Although little was known at the outset of this project about the frequency of combustion spillage, even less was known about how much of a health hazard such spillage represents. Therefore this sub-project was included to investigate the real nature of the health and safety risk associated with venting failures. The work was divided into five tasks -

1. Review of current knowledge on pollutant generation due to improper venting of combustion appliances (literature review).
2. Development of a computer program to predict levels of various pollutants under various combustion venting failure scenarios.
3. Acquisition and calibration of a set of instruments required to measure the various pollutants at the levels predicted by the computer model.
4. Monitoring pollutant levels in problem houses identified in the Country-wide Survey (Project 1) using the instruments acquired in Task 3.
5. Analysis of the results of Task 4 to arrive at an overall assessment of the health hazard represented by combustion venting failures in Canadian houses.

The results indicate that, in most houses, one would rarely encounter acute, immediately life-threatening concentrations of pollutants as a result of combustion spillage from furnaces or water heaters. However, chronic health risk due to low level, long term exposure to pollutants , particularly NO_2, may be a more significant problem which requires further investigation. High levels of CO do not seem to be caused by the problems which cause spillage and thus occur in spillage events only as a result of coincidence.

PROJECT 5 REMEDIAL MEASURES

Remedial measures for pressure-induced combustion venting problems were identified and researched for a number of different types of combustion appliances.

The remedial measures identified for FIREPLACES were:

Spillage Advisor
- This is an adjustable volume alarm triggered by a combination of particulate and CO detectors and intended to be mounted on the front of the mantle or on the wall just above the fireplace.

Airtight Glass Doors Combined With An Exterior Combustion Air Supply Duct
- The research indicated that conventional glass doors are not nearly airtight and do little to separate the fireplace from the house's pressure regime. Prototype doors using special glass, heavier than normal steel frames and special sealing techniques were fabricated and installed and tested. It was found that these doors increased the level of house depressurization required to cause prolonged spillage from the fireplace from 3 Pa to 22 Pa. It is estimated that the installed cost would be $600. Further research on the effect of airtight doors on temperatures within the fireplace and flue and the possible hazard to surrounding combustible materials is required.

The remedial measures identified for GAS-FIRED APPLIANCES were:

Spillage Advisor
- This could be similar to the fireplace spillage advisor but would be triggered by a heat probe mounted in the

dilution port of the appliance. The heat probes investigated could also be used to trigger other remedial measures discussed below.

Draft-inducing Fan
- A paddle-wheel-type fan mounted in the vent connector was found to increase the level of house depressurization required to cause irreversible spillage from a naturally aspirating gas furnace from 7 Pa to more than 20 Pa.

Draft-assisting Chamber
- A chamber surrounding the appliance's dilution port and extending downwards contains combustion products flowing out of the dilution port and prolongs the period before they are actually spilled into the room. It was expected that the chamber would also use the buoyancy of the contained combustion products to assist the flue in developing upward flow and thus would increase its resistance to house depressurization; however, the results obtained with the prototype tested did not live up to expectations. It is expected that modification of the design and testing with a furnace/flue/house combination more prone to pressure-induced spillage will improve this aspect of the chamber's performance.

The research on remedial measures for OIL-FIRED APPLIANCES indicated that stable backdrafting is unlikely to be a problem with oil-fired appliances since the pressure generated by the burner blowers is able to rapidly overcome backdrafting due to house depressurization and initiate upward flue flow. However, this pressurization of the flue system is what accounts for the start-up spillage associated with oil appliances and it is the duration of this spillage that remedial measures must address. The measures identified were:

Solenoid Valve
- By delaying the start of combustion until the burner has had a chance to overcome backdrafting and initiate upward flue flow, the solenoid valve reduces the duration of spillage but does not eliminate it altogether.

Draft-inducing Fan
- A fan, similar to that described above under gas appliances, mounted in the flue pipe downstream of the

barometric damper is not needed to overcome backdrafting since the burner blower can do this. However, it does relieve pressurization of that portion of the flue pipe upstream of itself and hence reduces spillage from that portion. There can still be spillage from the downstream portion; but, since that portion does not include the barometric damper, it is easier to seal.

Elimination of the Barometric Damper

- Provision of a well-sealed flue pipe without a barometric damper is one obvious way to reduce spillage. However, elimination of the barometric damper exposes the burner to the full chimney draft and disturbs the combustion process of conventional burners. Therefore this procedure must include replacement of the conventional burner with a high pressure burner which is less influenced by flue pressure. Provision of an insulated flue liner is often included as part of this measure.

The work on MAKE-UP AIR SUPPLY remedial measures was less directed towards specific measures but served to clarify a number of general air supply issues. It indicated that the provision of additional supply air is not likely to be effective as a remedy for pressure-induced spillage of combustion products if the supply air is introduced unaided through an envelope opening of any size likely to considered practical. It is only likely to be effective if a supply air fan is used and if that fan has a capacity at least equal to the total capacity of all exhaust equipment it is attempting to counteract. The discharge from such a supply air fan can be introduced essentially anywhere in the house, but is likely to create fewer thermal comfort problems if introduced in a normally unoccupied area such as the furnace room.

The knowledge generated in the remedial measures research and already available to Consortium members was synthesized into the draft Remedial Measures Guide, a manual intended to be a decision-making guide for tradesmen and contractors who have identified pressure-induced spillage problems in houses with vented fuel-fired appliances and want to know how best to remedy these problems. It is designed to accompany the Venting Systems Test. Although the draft Guide is not yet comprehensive and in some cases describes procedures which have not been thoroughly field tested and/or approved by regulatory authorities, it is hoped it will stimulate thought and discussion and improve current trade practices.

PROJECT 6 PROBLEM HOUSE FOLLOW-UP

Twenty of the houses identified in the country-wide survey as experiencing the worst combustion spillage problems were visited with the following objectives:

- to categorize and quantify the nature of venting failures
- to isolate contributing factors
- to collect field data on venting failures for use in the flue simulator model validation
- to measure the frequency and quantity of spillage in problem houses
- to measure the approximate impact on air quality of venting failures in houses
- to evaluate the effectiveness of the chimney safety tests in diagnosis of failures and identification of remedial measures
- to evaluate communications techniques
- to evaluate remedial measures under field conditions

In most of the houses, there were several factors that were assessed as contributing causes of the combustion spillage problem - thus confirming the "systems" nature of the problem. It is also worth noting that, in many houses, although the spillage observed was indeed pressure-induced, it occurred at quite low levels of house depressurization because the chimneys were only able to generate very weak draft due to some problem such as a blocked or leaky flue. The main problem in these cases, therefore, was not depressurization but weak chimneys.

PROJECT 7 COMMUNICATIONS STRATEGY

As the survey revealed that the problem, while substantial, is not epidemic in proportion, there is no need to create widespread alarm in the general public. A communication strategy has been drafted with this in mind. It places emphasis on motivating the heating and housing industries to be aware of the combustion venting problem and its causes and to make effective use of the diagnostic tools and preventive and remedial measures developed in this project.

OVERALL PROJECT SUMMARY AND CONCLUSIONS

The project has gone a long way towards meeting its original objectives and has significantly advanced the state-of-the-art in this field.

It has led to improved understanding of the combustion venting process and confirmed the "systems" nature of the failures that lead to combustion venting problems.

It appears that a significant portion of the Canadian housing stock has potential for combustion venting failure to occur on a regular basis. In most cases, this is unlikely to lead to immediate life-threatening pollution levels, but long term chronic health hazards could be a problem; however this latter concern requires further investigation before any definite conclusion can be reached.

A number of techniques are available for identifying houses prone to combustion venting failure and for diagnosing the causes of such failure. There are also available a number of measures for preventing combustion venting failure in new houses and for remedying it in existing houses. A communication strategy has been drafted for conveying these techniques and measures to relevant people in the housing and heating industries and for encouraging them to make use these tools.

APPENDIX B

RESEARCH PLAN FOR OIL-FIRED REMEDIAL MEASURES

January 27, 1986

PROJECT 5: REMEDIAL MEASURES RESEARCH; Oil Combustion Units

1.0 IDENTIFICATION OF PRIORITIES

The Atlantic Region is one of the last areas where a major percentage of residential heating is still provided by oil appliances. Aside from improvements in burner hardware and flue construction techniques there is little research into remedial measures for these existing units. This is due primarily to the fact that the majority of houses, those built prior to 1975, seldom have combustion venting failure. (Although in older homes there is often evidence of spillage or puffing at start up not considered as venting failures.) In the case where houses built within the last ten years have failed backdraft tests, the homeowners are either unaware of the venting failure in their homes or accept these conditions as consequences of new insulation and building practices. Further, the burner service industry is not addressing these problems because of the lack of tested remedial measures and products available to them.

Our initial research into remedial actions for oil fired appliances centers on these five areas of work:

1. Combustion air supplied directly to the furnace or boiler.
2. Pre-purge cycle for residential applications utilizing either the burner fan or external draft inducers to overcome venting failure.
3. Exhaust appliance prioritization using electrical interlocks with combustion equipment.
4. Sealed combustion appliance systems. These systems include new burner and flue technology.
5. Spillage and backdraft alarms

Of these five the combustion air supply (1) and the sealed combustion system utilizing a forced draft burner and an insulated and downsized flue liner (4) were identified as two priority remedial actions for oil fired combustion units by resource personnel. These two areas of development have received the most study to date:

> Several air supply systems for combustion appliances are available in the marketplace. Sealed combustion units are being aggressively marketed by at least two major oil companies. As well, these new burner systems have prompted a significant amount of research into insulated flue and cap design and flue sizing.

> Combustion Air supply should be considered as a priority recommendation in homes with venting failures. We have installed a number of these devices as a result of previous backdraft testing. We will be very interested to see SRC's work in this area.

Electrically interlocking combustion appliances with exhaust equipment (3) and Spillage and backdraft alarms (5) were considered important as low cost safety options:

> Moffat's work using a relay to shut down the furnace burner when powerful exhaust fans are in use is a failsafe approach to venting failure problems caused by the simultaneous use of exhaust appliances. This method is well documented and the technologies for installation are easily accessible.
>
> We have seen several alarm devices for gas combustion appliances and we expect that these devices will shortly be available for oil fired appliances as well.

Pre-purge cycle for residential oil systems

In consultation with Rod Arsenault of Holland College, we propose to look more closely at pre-purge cycles (common to commercial boilers) as they might be applied to residential oil heating equipment. In commercial burners this cycle establishes positive draft prior to combustion utilizing the forced air burner fan . In discussions with others there was some ambivalence about the burner fans ability to overcome backdrafting. Previous work by Moffat on one furnace indicates that cold furnace (no combustion) pressure measurements at the breech were consistently 30 pa. (.12" water) with the burner fan operating. We found this figure intriguing because if it is repeatable on other furnace makes, pre-purge cycles could be utilzed as a remedial measure to overcome backdraft prior to furnace startup.

The research will involve testing and analysis of two remedial actions concerning Pre-purge cycles:

1. Testing and Assessment of the burner fan's ability to establish significant pressure to overcome backdrafting when utilizing a delayed action solenoid.

2. Testing and assessment of pressures developed by induced draft kits interlocked with furnace burner and /or exhaust appliances.

Justification of Priorities

Usefulness and repeatability of the remedial measure:

Pre-purging cycles are commonly used in commercial boilers to overcome backdrafting prior to ignition. Conceptually this technique is transferable to residential equipment to solve similar draft problems.

Preliminary testing indicates that standard residential equipment can be modified simply with CSA approved materials to incorporate the new cycle.

It is probable that pressures produced by the furnace fan and/or induced draft kits will be sufficient to overcome negative pressures developed by exhaust appliances used in the household.

Cost of the remedial measures will be low.

Technology of these measures is understood and easily transferable to the electrical and burner service industry.

Conclusions of study:

The study will be conducted under controlled conditions giving accurate test results and data for each remedial measure.

Several different burners and furnace types will be tested under similar lab conditions providing uniformity of results.

Remedial measures will be analyzed as to ease of installation and cost of equipment during the progress of the tests.

2.0 RESEARCH PLAN FOR PRE-PURGE CYCLE TESTING

Remedial Measure #1 - Delayed Action Solenoid Valve

Background: The installation of solenoid valves in the maritime region has been an energy conservation recommendation for several years and eligible for funding under several past government programs. The devices were originally marketed for oil savings of approximately 3%. Many of the solenoid devices that were installed were the 8 second delayed action variety. Under one government program furnace servicemen throughout PEI were trained to install these units and there is now a general acceptance of the device.

Discussion: The delayed action solenoid valve delays the flow of oil to the burner for a specified period of time allowing the burner fan to establish an updraft in the chimney prior to ignition. In addition the delayed action solenoid valve may eliminate spillage and puffing at startup by allowing the oil pump to reach maximum pressure for atomization of oil prior to ignition. The theory is that this device has the ability to establish draft in the chimney overcoming negative pressures within the home caused by exhaust appliances. Moffat's cursory tests indicate that delaying combustion allows the furnace fan to develop relatively high static pressure within the flue pipe under cold combustion chamber conditions.

The air pressure created by the average burner (1750 RPM) is about .25" water (60Pa) measured in the burner air tube. Moffat's measurments at the breech of .12" water (30Pa) indicates an ability for the furnace fan to develop significant pressure to establish draft in the chimney.

However, there is some skepticism about the ability of the burner fan alone to overcome backdrafting. Although the fan has the ability to develop 60 Pa pressure in the air delivery tube, turbulance and resistance of the heat exchanger and smoke pipe might significantly reduce any ability of the fan to overcome negative pressure and establish updraft. (Note the significant pressure drop between the assumed air pressure in the burner tube and Moffat's air measurements at the breech of the furnace.)

It is the purpose of this research to determine how various fans in boilers and hot air-furnaces vary in their ability to overcome backdrafting. The method of testing and results are outlined later in the research plan.

Remedial Measure #2 - Induced Chimney Draft

Background: Induced chimney draft may prove to be an appropriate remedial measure in homes experiencing negative draft pressures which cannot be safely overcome by burner fans and thermal draft. Chimney draft is induced by installing a low horsepower fan directly in the flue pipe. Induced draft kits are now available. The investigation of these devices will determine whether they can eliminate the use of the barometric damper, control cold back drafting and overcome significant negative pressure within the household.

Discussion: The induced draft fans will be run through a test regime (similar to that used in testing the furnace burner fan) to determine the characteristics of operation and MAD limits. The fan will be used in conjunction with a delayed action solenoid valve on the burner. Several methods of controlling the induced draft fans are under consideration:

> Control operation of the fan by means of the household thermostat. The delayed action solenoid will allow the fan to develop draft in the chimney prior to combustion.
>
> Interlock induced draft fan to exhaust appliances by means of a relay to power fan whenever exhaust appliances are in use. This method of control may reduce the possibility of cold or hot backdraft tendencies.
>
> Control induced draft fan by means of a differential pressure switch sensing chimney draft. The proving switch would activate the fan when pressure within the chimney dropped below .01" of water. Using this control may reduce hot and cold backdrafting.

These methods of controlling the induced draft fan will be assessed after the following tests indicate the potential of this remedial measure to overcome venting failures.

3.0 PROPOSED METHOD OF RESEARCHING REMEDIAL MEASURES

The objectives of these tests are to determine the effectiveness and ability of each remedial measure to overcome backdrafting under controlled conditions.

The testing will take place at the Holland College Energy Systems Technology Centre. These facilities include a library of research work and manuals for oil combustion furnaces and a workshop for fabrication and installation of test equipment. The remedial measures will be tested in a furnace room with two furnaces, a hydronic system and a forced air system. These furnaces can be fitted with several different burners.

Variables to be considered and required equipment are listed below.

VARIABLE	MEASURE / CONTROL
Furnace room pressure (Pa)	Retrotec Door Fan
Pressure in flue (Pa)	Dwyer Manometer
Delay (seconds)	Universal variable delay timer with solenoid valve Stopwatch
Draft direction	Smoke Pencils
Outdoor temperature, wind speed and direction	Weather office

The tests below will be conducted on both a hot air furnace and boiler utilizing several different burner makes.

Description of Tests:

Test 1. Static pressure induced by fans

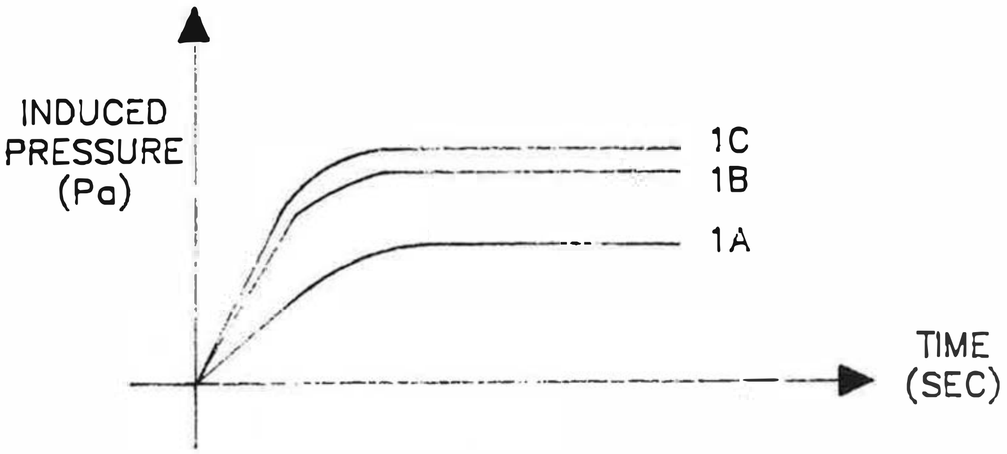
Condition: Flue Blocked
Monometer to measure pressure inside flue pipe vs time

1a. Burner fan operating and flue pressure will be recorded over time until steady state pressure is reached.

1b. As above, but draft inducer fan replaces burner fan.

1c. As above, with both fans running together.

Data will be graphically displayed in a pressure v.s. time graph as below:



Results will determine:

- time required to reach maximum fan effectiveness.
- maximum pressure each fan is capable of producing.
- a comparison of boiler and furnace characteristics.

Test 2. Backdraft & Spillage points (cold)

2.1 With burner fan on, the room will be gradually depressurized until spillage and backdraft occur.

2.2 As above, but using draft inducer.

2.3 As above, using both fans.

Results will determine:

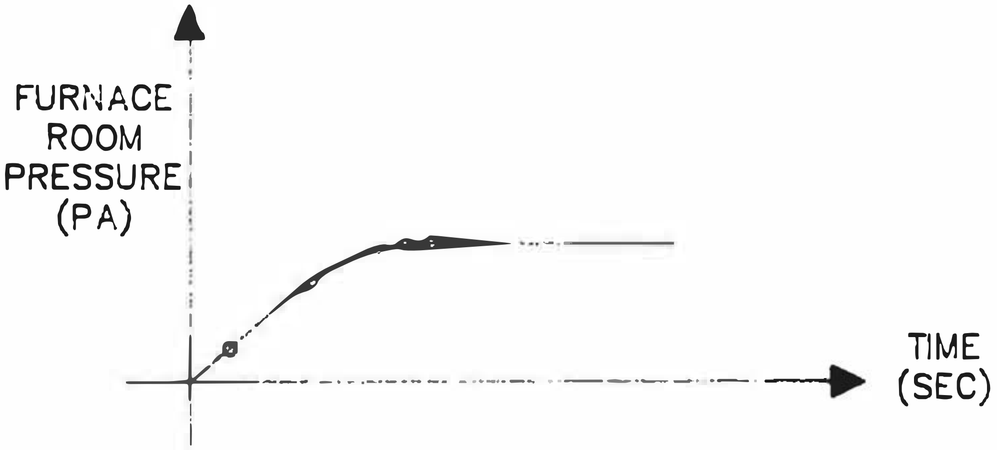
- Absolute MAD (cold) in Pa.

Test 3. Solenoid Delay Time Required to Establish Updraft

Starting with the fan off, the time required to establish updraft will be measured at a series of appropriate depressurization levels.

Results will determine:

- Actual MAD (cold)
- Maximum practical delay



Data will be graphically displayed in a pressure v.s. time graph.

Test 4. Backdraft and Spillage Tests (Hot)

With the burner firing, Tests 2.1, 2.2, and 2.3 will be repeated.

Results will determine:

- Absolute MAD (Hot).

It is likely that further tests will be included as this work develops. The remedial measures will be assessed on the basis of equipment installation, cost and data collected during the test period and presented in the final report.

APPENDIX C

SOLSEARCH FINAL REPORT

March 16, 1987

RESIDENTIAL COMBUSTION VENTING FAILURES:

A SYSTEMS APPROACH

PROJECT 5

PRIORITY REMEDIAL MEASURES FOR OIL APPLIANCES

Solenoid Valve
Induced Draft Fan
High Pressure Burner With
Damperless Insulated Flue

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March 16, 1987

RESIDENTIAL COMBUSTION VENTING FAILURES: A SYSTEMS APPROACH

Project 5
Priority Remedial Measures for Oil Appliances

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1. SUMMARY

This work, by Solsearch Inc., is part of the CMHC project, "Residential Combustion Venting Failures - A Systems Approach", managed by the Scanada Sheltair Consortium.

Six potential measures which could reduce spillage or backdrafting in oil fired combustion systems were assessed and the three most practical measures were chosen for testing.

Spillage occurs when a portion of the combustion products vents into the house. Backdrafting occurs when the flow in the chimney is reversed, and under this condition, all combustion products vent into the house.

The three measures tested were: (1) a delayed action solenoid valve; (2) an induced draft fan; and (3) a high pressure burner with a damperless, insulated flue.

The first series of tests tested the ability of a conventional burner fan to reverse flow in a backdrafting chimney, under different levels of house depressurization. The second series of tests measured the static pressure obtainable by the burner fan and/or draft inducing fan with a blocked flue. The third series of tests determined the level of home depressurization at which a boiler would begin to show spillage. The fourth series of tests were field testing of high pressure burners and damperless, insulated flues installed in two houses.

These limited tests demonstrated that the remedial measures suggested for oil furnaces seem to be suitable ways to minimize combustion gas spillage.

The induced draft fan, especially if used in conjunction with a solenoid delay on the burner, can reverse backdrafts and minimize spillage under any likely house depressurization. Downstream of the fan there may be some start-up spillage at flue pipe joints, unless these are properly sealed. There was no investigation of the effect of the fan on furnace/boiler burner performance.

The delayed action solenoid gives sufficient time for the burner fan to reverse an initial backdraft. It does not prevent spillage from the unintentional or intentional holes (eg. damper perimeter), although by better establishing proper flow in the chimney, it may reduce the duration of spillage. By a thorough sealing of the flue pipe and all connections, this spillage will be further reduced. No measurements of the effects of the remedial measures on spillage duration were undertaken during these tests.

The damperless, insulated flue and high pressure burner does create an improved chimney draft and fewer holes for flue gas spillage to occur. The margin of improvement is not as great as with the induced draft fan and the cost of this retrofit is quite high. It seems to be a good option for homeowners with a furnace/boiler in good condition and a chimney in need of repair (or suffering from condensation problems).

2. INTRODUCTION

The CMHC project, "Residential Combustion Venting Failure - A Systems Approach", is the culmination of several years of research into chimneys that fail to properly vent exhaust gases. As part of the 1986 research, remedial measures were to be investigated to counteract the spillage of combustion products from oil, gas, and wood-burning appliances. The Scanada Sheltair Consortium, which managed the project, chose Solsearch Inc., of Prince Edward Island, to undertake the research into remedial measures for oil-fired systems. A description of typical oil furnace operation, for those unfamiliar with the process, is included in Appendix 1.

After discussions with various authorities, a list of six measures was created (see Appendix 2). These were assessed in turn to produce a short list of three devices that were feasible, practical, and suitable for testing: (1) Delayed Action Solenoid Valve; (2) Induced Draft Fan; and (3) High Pressure Burner/Insulated Flue.

The first two devices were laboratory tested. A delayed action solenoid valve allows the fan on the oil burner to activate before the oil flow is started. The combustion chamber, and at least the base of the chimney, is pressurized by this fan flow, and the theory was that this initial pressurization could reverse a backdrafting chimney before the burner fired and combustion products were created.

The induced draft fan, mounted on the flue pipe, pulls the products of combustion out of the combustion chamber and then pushes this air flow up the chimney. Because the induced draft and burner fans create different pressure regimes in the furnace-flue pipe-chimney system, they would have to be tested both separately and together. These tests were undertaken at the Holland College Energy Systems Technology Laboratory.

The third suggested remedial measure is the "high pressure burner/insulated flue combination" recommended by ESSO Canada. To test the improvement of draft and the reduction of possible spillage due to this system, two houses were retrofitted with the burner/chimney. Tests before and after the installations showed the draft improvement. The possible condensation prevention, due to the chimney insulation, was not investigated.

3. PROCEDURE

The first two remedial measures, the delayed action solenoid valve and the induced draft fan, were tested at the Holland College Energy Systems Technology Laboratory. The geometry and dimensions of the boiler/flue pipe are detailed in Figure 1. Note that there are 6.3 metres of flue pipe and chimney inside the building and less than a metre above the roof. Essentially, this installation is an internal chimney and should show little susceptibility to outside temperature in regards to flue gas cooling. Points A and B on Figure 1 are 6mm holes in the flue pipe, used for observation, and Point C is the inspection port on the face of the boiler.

The boiler is a Kerr Model A3 & A4. Several burners were fitted to it sequentially:

Conventional burner:	Aero Environmental, Model FAFC 1.25 USGPH nozzle Fan rpm 1725 Solenoid delay 8 seconds
High pressure burner:	Riello Mectron M3, Type 215 TC 0.60 USGPH (a 0.95 USGPH nozzle was tested separately) Fan rpm 3250 Solenoid delay 12 seconds Air supply damper closes when unit not operating

Modifications were made to the burners to allow the oil supply to be cut off, even though the burner had been activated (see Figure 2). This allowed the testers to keep the flue cool, if desired, when running a series of "start-up against backdraft" tests.

The draft inducer was a Tjernlund Autodraft, Model D2, paddle type which was mounted on the flue pipe about 1m from the boiler (see Figure 1). The inducer did not affect the flow of flue gases when not in operation. See Appendix 3 for details of the inducer.

To model negative house pressure in the laboratory, a Retrotec RDF 400 door fan was installed in one of the laboratory doors. The pressure measurement was by a Dwyer Durablock Model 115 manometer with a reading accuracy of about 0.3 Pa. However this apparent accuracy should be qualified by windy testing conditions which made the manometer oscillations ± 1 Pa. If the pressure fluctuations exceeded this figure, testing was aborted.

There are some discrepancies in terminology in the test reporting. In the original testing, as shown in the Glossary and the raw data appended, there were two spillage points observed. "Cross-over" occurred when the candle flame indicated varied flow in, and out of, the observation hole. "Spillage" was defined as continuously outward flow of combustion gases from the flue to the room. In the body of the report, the "cross-over" data has been used to indicate that spillage is starting, and this data is labelled as "spillage" data.

Figure 1 - Burner and Flue Geometry

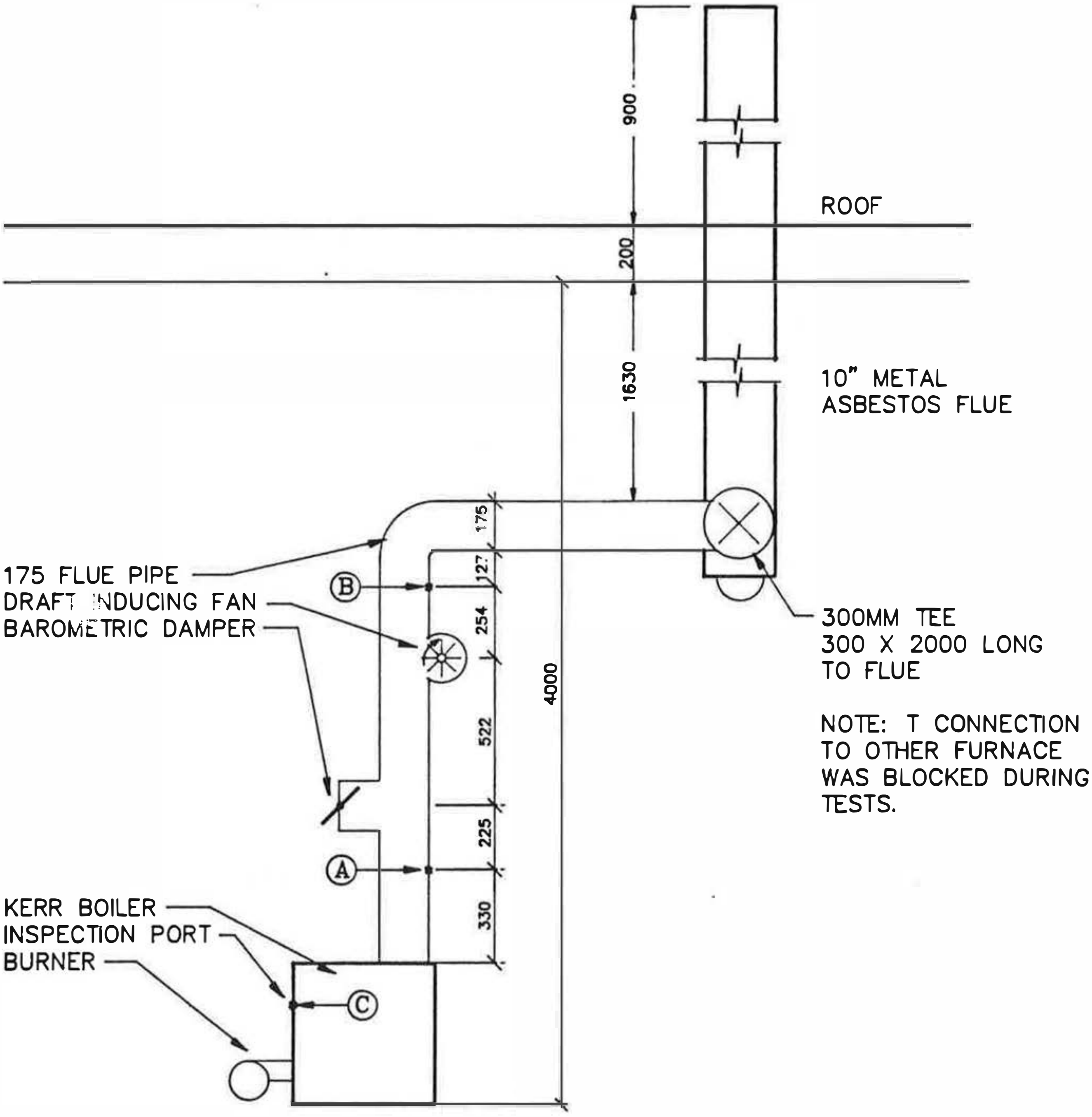
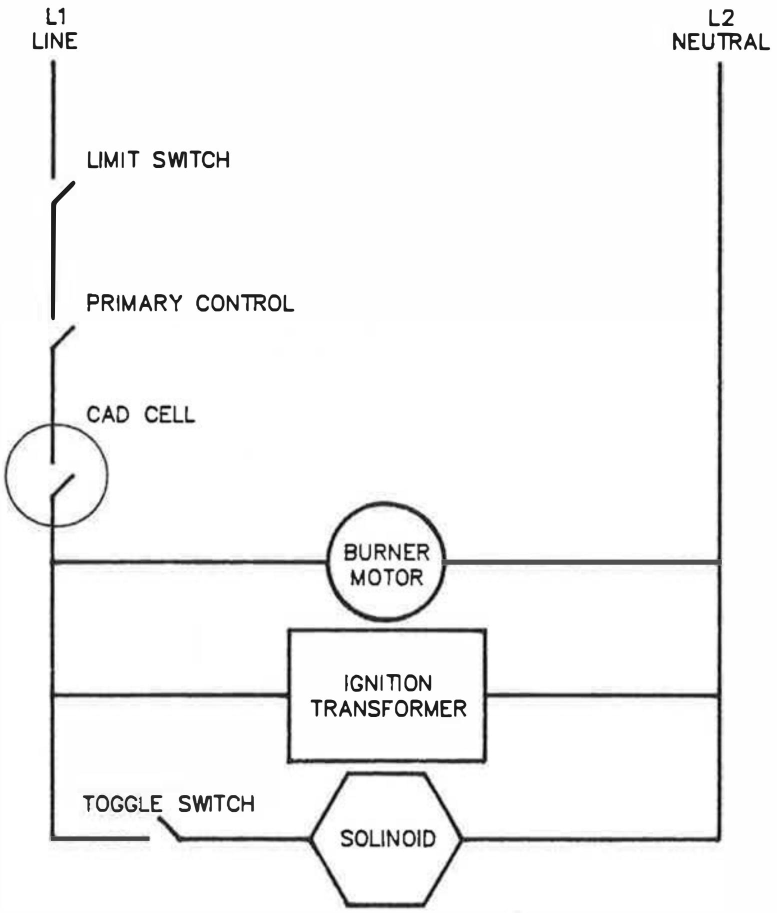


Figure 2 - Circuit Diagram of Conventional Burner



NOTE: The toggle switch is used to delay the oil coming into the combustion chamber.
The burner is allowed to run and induce air movement into the Flue without combustion.

After burner fan started the cad cel terminals were shorted to prevent shut–down.

Figure 2 Circuit Diagram of Conventional Burner

3.1 BACKDRAFT TESTING

The first series of tests was performed to establish whether a burner fan or a draft inducer, during the solenoid delay before the burner ignites, could reverse a backdrafting chimney. If a chimney has cooled during the off-cycle and house depressurization causes the chimney to act as an air supply to the house, chimney flow must be reversed upon furnace or boiler start-up. Without any delay in burner activation, such situations result in furnace backpuffing and rumbling. The tests were performed when outside temperatures were approximately -10°C. Chimney temperatures approached -10°C after extensive backdrafting. Colder conditions would have provided a more difficult environment for draft re-establishment, as chimney pre-cooling would be more severe.

The tests were performed with the laboratory room depressurized to discreet levels by the door fan, to a maximum of 60 Pa. The system was run against a variety of depressurizations, and the times were recorded when the backdrafting flow was effectively stalled by the burner fan flow. This was indicated by the visually observed reversal of smoke flow of a smoke pencil centred in the smoke pipe (Point A).

A second series of flow testing was undertaken with a velometer air flow meter installed in the flue pipe. The burner fan was activated, without oil flow, to aid the natural draft of the chimney. The room was then slowly depressurized to 85 Pa, with the flue pipe air flow being recorded.

3.2 STATIC PRESSURE TESTING

On a more general basis, some tests were performed to determine the time vs. pressure characteristics of the fans involved. The different burner fans installed on the boiler, including a 0.95 USGPH high pressure burner, were activated with and without the draft inducing fan. The pressure in the flue pipe, at Point B, was measured with the Dwyer manometer, and time required for the pressure rise recorded by stopwatch. The fan curves produced are unique to this boiler/flue pipe system and are referenced only to the one point of pressure measurement at Point B. These tests were performed without oil flow and represent only the pressures that the burner fans could produce. Thermally-created draft was not a factor in these tests and the flue pipe was blocked at the chimney.

A final test was undertaken to establish the leakage characteristics of the flue pipe itself. With the conventional burner fan activated and the flue pipe disconnected from the chimney and blocked, the pressure in the flue pipe was measured at Point A. To view the effects of the pipe leakage, this test was re-run with all joints, test holes, and the barometric damper sealed with aluminum tape. A third test involved removing the flue pipe from the boiler, blocking the boiler exhaust, and sampling the burner fan pressure through this blockage. This establishes the range of possible pressures and points to the sections where pressure losses and spillage locations are created.

3.3 SPILLAGE TESTING

The previous tests determined whether, and by what margin, the burner fan or draft inducer was able to reverse an initial backdraft. The tests also delved into the leakiness of the boiler/flue pipe system.

Spillage testing is not related to flow direction (eg. normal upward exhaust vs. backdrafting), but whether the components of the system are at a higher pressure than the surrounding room air. If the flue pipe-to-house pressure is positive and leakage areas exist, the exhaust gases will spill into the house air in varying amounts.

Testing was performed on the same laboratory set-up as in Figure 1 and evidence of spillage was recorded at Points A, B and C. Spillage concerns the exhaust products that actually enter the house air. A remedial measure designed to prevent backdrafting may still cause spillage, especially if limited in time. It is, however, less of a safety problem than backdrafting.

The recording of spillage was quite subjective; it was determined by the use of a candle flame or smoke pencil. See the raw data in Appendix 4 and the definitions in the Glossary to appreciate the subtle distinctions between "cross-over", "spillage", and "puffing". Consider the transitions in a dynamic situation, be it a backdraft reversal or boiler start-up, and how they may be affected by fluctuating winds outside. Factor in instrumentation lag and reading error, and, only then, look at the spillage testing section. Results, shown in Table 2, are probably good to approximately ± 2 Pa, so 5 Pa differences are generally significant.

The spillage tests were performed in the same variety of systems as the preceding backdraft tests. In this case, the burner fan or induced draft fan was activated, without oil flow and burner activation. When operating pressures were established, the door fan was used to create a laboratory depressurization. Spillage was monitored at Points A, B and C under varying levels of depressurization. To simulate operating burners, the boiler/flue pipe was heated up by the burner for 15 minutes to create a "hot flue". The burner oil flow was then shut off for the "hot flue" testing. This procedure was used to minimize progressive heating of the flue with burner operation, but flue gas temperatures during "hot flue" testing still varied widely (from 87-196°C). This variation certainly affected the test results.

3.4 FIELD TESTING OF THE DAMPERLESS, INSULATED FLUE WITH HIGH PRESSURE BURNER

The remedial measure "damperless flue with high pressure burner" was developed and promoted by Imperial Oil Canada. It was recommended by a member of the project Advisory Committee, Harry West of ESSO. See Appendix 3 for details on the chimney installation.

The system consists of a high pressure burner (similar to those already mentioned), and a seamless, insulated flue liner installed in the existing masonry chimney, complete with wind-diverting cap. There is no barometric damper in the system.

Two houses were selected for retrofit with this remedial measure. Both were relatively new R-2000 type houses with 200x300mm masonry chimneys. Each of the homes was tested in 1984-85 as part of the Residential Combustion Safety Checklist research project. One of the houses already had high pressure oil burners without barometric dampers installed on a boiler and hot water heater. Attempts were made to locate houses with draft failures due specifically to oversized masonry chimneys, without success. It was noted, however, that both flues in the test houses, though only two years old, had chipped liners, signs of condensation and frost damage.

A detailed description of the two houses follows:

PIERCY HOUSE

Type: single family

Structure: 1-1/2 storey with basement

Insulation: R-2000 standards

Tested air leakage: 1.43 ACH at 50 Pa
$C = 6.26\ l/(s \cdot Pa^n)$
$n = 0.86$

Heating system: oversized boiler; 2.00 GPH capacity

Burner: conventional Aero before retrofit
Riello M3 high pressure burner after retrofit
.65 USGPH nozzle

Barometric damper: yes before; none after

Age of boiler: 8 years

Nozzle size: 0.75 USGPH before; 0.65 USGPH after

Chimney: 200x300mm flue with ceramic liner; 7.2 m height

Special equipment: air-to-air heat exchanger; clothes dryer

Previous testing had shown spillage when the air-to-air heat exchanger was sealed and the clothes dryer (located in the basement) was operating. Two heat sensitive discs affixed to the barometric damper had changed colour. indicating that spillage had occurred. The owner reported the smell of oil fumes present when the clothes dryer was operating.

LOSIER HOUSE

Type: single family

Structure: bungalow with basement

Insulation: R-2000 standards

Tested air leakage: 0.26 ACH at 50 Pa
$C = 2.46\ l/(s \cdot Pa^n)$
$n = 0.70$

Heating system: oil hot air furnace and oil hot water heater

Burners: Riello M3 high pressure burners

Barometric dampers: none

Age of furnace: new

Nozzle sizes: 0.40 USGPH

Chimney size: 200x300mm flue with ceramic liner;
5.56 m height

Special equipment: air-to-air heat exchanger; clothes dryer

Previous testing had shown spillage when the air-to-air heat exchanger was sealed and the clothes dryer (located in the basement) was operating.

The owner had complained of the smell of oil fumes in the basement but had attributed the problem to an imbalance in the heat exchanger system. As a solution he had adjusted the heat exchanger to induce a slight positive pressure in the house.

Flexible 125mm stainless steel liner kits were sized and supplied by Esso Petroleum Canada. The kits also included double base "T's" and special Aerocowl caps designed to reduce the effect of the wind on the draft. Waterproofed Vermiculite specified for insulation was not available. "Perlite", a volcanic, waterproof block fill, was used for insulation instead. 125mm connecting flue pipes were made locally of sheet steel. The insulated flue liners were installed by masons. The installation procedure is fully documented in the installation manual. (See Appendix.)

In the Piercy home, the existing oil burner was replaced with a new high pressure burner (Riello M3) with an integral air supply damper and delayed action solenoid valve. As recommended by the manufacturer, the nozzle size of the new burner was 15 percent smaller than that of the replaced burner to account for the increased oil pressure of the new burner. The two existing high pressure burners at the Losier home are also M3 Riello burners.

Four tests were performed on these houses using a Dwyer manometer, a candle to indicate spillage at a 6mm hole in the flue pipe, and the doorfan to create house depressurization.

1. Cold flue spillage

   - To what house depressurization could the off-cycle flue pipe resist spillage of flue gas into the room air?

   - If the house has two oil appliances (Losier house), how does one appliance affect the other?

2. Hot flue spillage

   - How much would heating the flue (by operating the burner with oil flow) improve the draft?

3. Maximum house depressurization against which normal burner operation could re-establish upward flow.

   - What is the maximum house depressurization that the burner fan can overcome at start-up? (tested post-retrofit on Piercy house only)

4. House depressurization by the use of house fans only

   - To what levels of depressurization can the exhaust appliances bring the house? (clothes dryer and air-to-air exchangers tested under worst case conditions)

4. RESULTS

There is a distinction to be made between remedial measures that address backdrafting and those that deal with spillage. At times, these measures can be counterproductive. A high capacity burner fan will be more apt to reverse an initial backdraft, but will also provoke more combustion gas spillage out the observation port or barometric damper of a conventional furnace.

Effectiveness of the remedial measures may also be somewhat obscured by the wealth of data. On testing a delayed action solenoid valve as a remedial measure, the time lag of the device can be accurately established. The tests undertaken were designed to show if such a time delay would permit various burner fans to establish an updraft under adverse conditions. The results of these tests are unique to the equipment used and weather conditions at the time of testing. The universality of the measures can be inferred from the data but there is a degree of uncertainty involved.

The backdraft test shows that the burner fan is capable of reversing chimney flows at up to 60 Pa negative pressure, more than any likely house depressurization. The flow reversal happens in less than 1/2 second, well within the 8 to 12 second delay of a solenoid valve. (See Appendix 4 for detailed data.)

The chimney flow velocities under increasing depressurization are charted in Figure 3.

The burner fan easily creates positive flow up to 30 Pa, and marginally from 30 to 60 Pa, before the chimney flow reverses. The rate of increase of door fan flow during testing may have affected this point of flow stalling.

Note that these two tests were made with a 1.25 USGPH conventional burner only. Results for other burner types or nozzle sizes can only be inferred. In one case, a 0.65 USGPH high pressure burner with oil flow clearly was unable to start at a negative pressure of only 15 Pa. (Piercy house, post-retrofit). Flow direction was not measured in this latter case, but failure of the the combustion process may occur well before actual chimney flow reversal due to changes in the oil/air mix.

The fan characteristic testing shown in Figure 4 is taken from data in Appendix 4. In these tests, the burner fans created static pressures in the blocked flue pipe, measured at Point B. The conventional burner eventually produced only 10 Pa at Point B, compared to 15-20 Pa for the 0.95 USGPH nozzle or the draft inducer acting alone. When the draft inducer acted together with either burner fan, roughly 30 Pa of pressure was produced in the flue pipe. The standard 0.60 USGPH Riello burner fan produced only 4 Pa.

The same burner fan with a 0.95 USGPH nozzle produced over three times the pressure and it can be inferred that the ability of the burner fan to reverse backdraft would be very dependent on nozzle size. The combustion air supply is adjusted according to the nozzle size, (more oil, more air), indicating that the fan's ability to develop pressure is dependent on the air supply.

Table 1 shows how the pressure characteristics are affected by the leakiness of the flue pipe. With the flue pipe blocked at the chimney, 19 Pa of static pressure is developed. Sealing the damper, joints, and observation holes triples this pressurization to 56 Pa.

Spillage generally ocurs at much lower levels of depressurization, and results fluctuate considerably due to changes in wind, exterior temperature, chimney temperature and measurement location. Results are shown in Table 2 (and in Appendix 4). The following generalities can be extracted:

1. The effect of the burner fan is variable. At measurement Point B, when the burner fan is activated, the now pressurized flue pipe will spill at a lower depressurization than with no fans. At Points A and C, spillage with the fan is at higher depressurizations with a hot flue. A possible explanation is that, in the "Hot" tests, the boiler water and boiler heatchanger is hot. The fan flow carries this heat to the chimney, creating additional draft.

2. The draft inducer prevents spillage upstream (eg. Points A and C) at room depressurizations of 20 Pa and more. Downstream towards the chimney, where it pressurizes the flue pipe, spillage is apt to occur at under 8 Pa room depressurization when the flue is cold, and about 10-19 Pa when hot.

For the damperless, insulated flue with a high pressure burner, the results are also affected to a large degree by the weather conditions during testing. In Table 3 and Appendix 5, no cold flue improvement is seen in the Losier house, but the pre-retrofit testing conditions were much more conducive to good draft. With a hot flue, results are too variable for any conclusions. High winds during testing are blamed.

The Piercy house showed an off-cycle draft increase from 2 to 6 Pa with the retrofit, and from 8 to 15 Pa on the hot flue. Note that these houses can be depressurized by their own fans to 7.5 and 5.6 Pa respectively (see Appendix 5). This shows that the margin of safety in preventing cold flue backdraft is minimal.

The maximum Piercy house depressurization against which draft could be re-established (against initial backdraft) was 8-10 Pa using the burner fan only, and 13-15 Pa with both burner and burner fan activated. These results are for the post-retrofit case only. No data is available for the pre-retrofit systems.

Figure 3 - Effect of Depressurization on Flue Pipe Flows

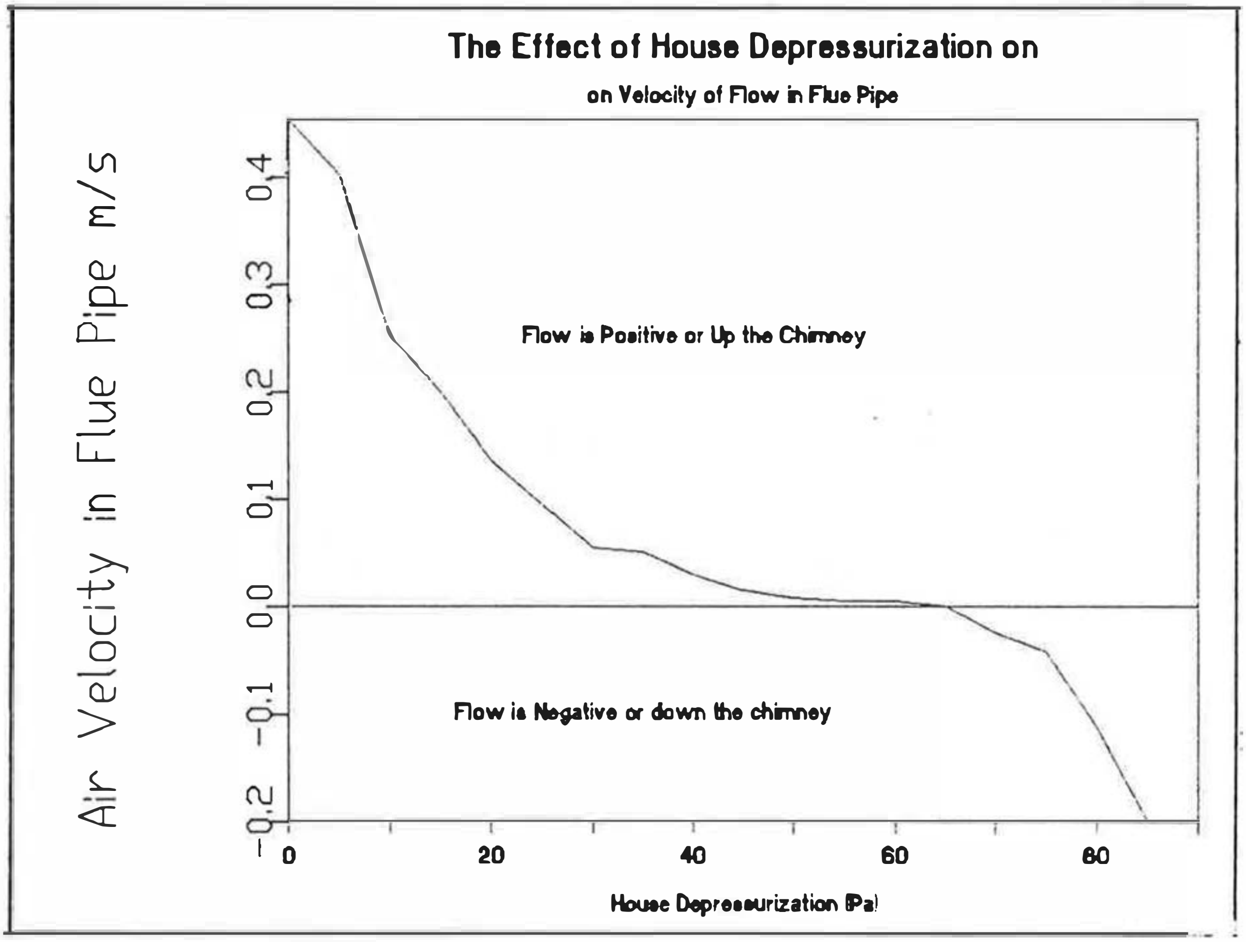


Figure 4 - Measured Fan and System Characteristics

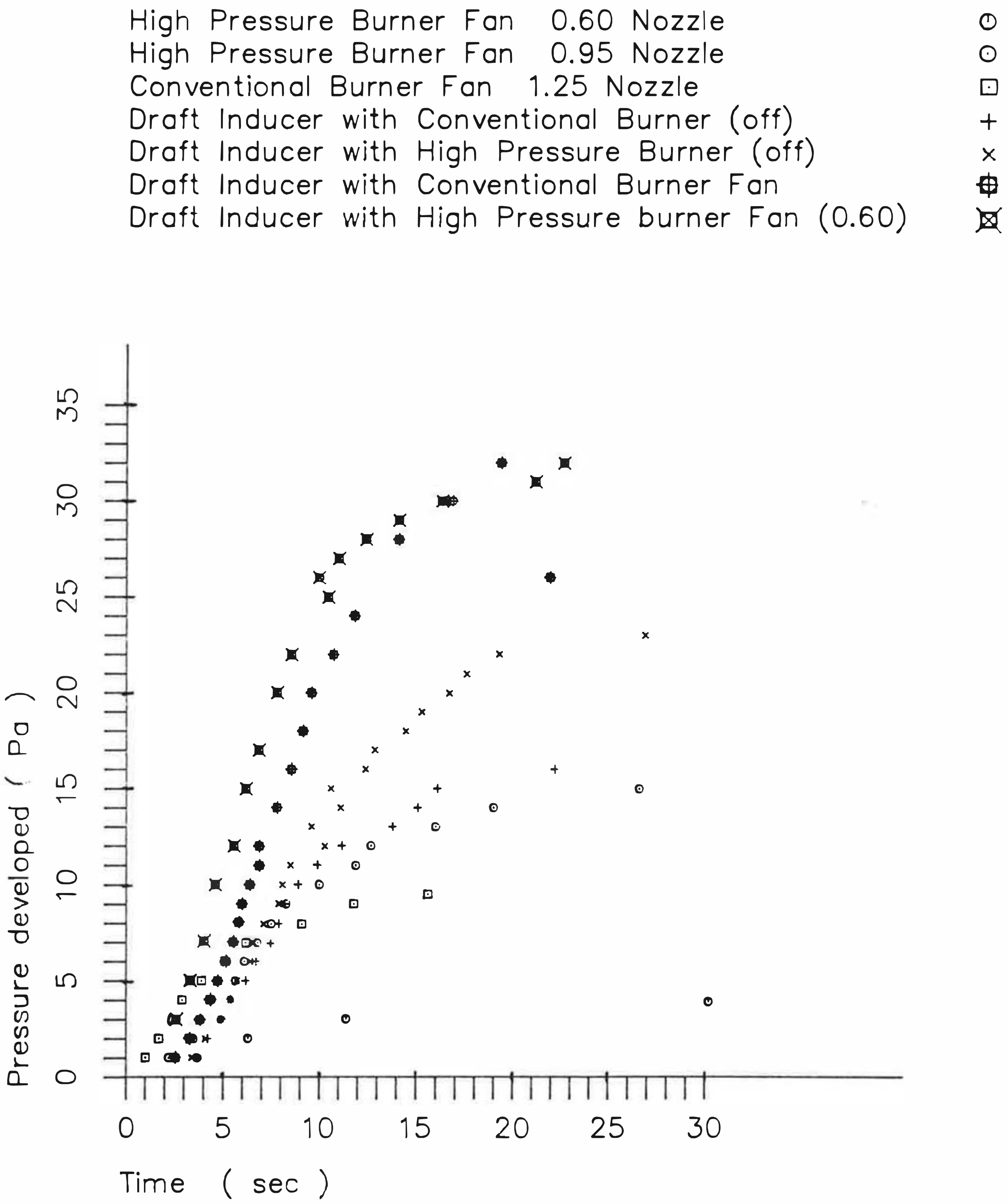


TABLE 1 COMBUSTION PATH LEAKS

Condition:	Static pressure developed by oil burner (no oil flow) Pa
Flue pipe blocked just before entering metal chimney	19
As above. All joints and barometric damper sealed with duct tape.	56
Flue pipe removed from boiler and outlet sealed.	70

TABLE 2 RESISTANCE OF OPERATING SYSTEM TO DEPRESSURIZATION

Pressure at Which Spillage was Observed (to nearest Pa)

Observation Point	Conventional Burner		High Efficiency Burner	
	Spillage at Pa		Spillage at Pa	
Condition 1: No fans				
	cold	hot	cold	hot
Point A	3	4	6	6
B	2	5	3	6
C	3	5	6	7
Condition 2: Burner fan only				
Point A	0	9	2	9
B	1	6	1	5
C	0	13	2	14
Condition 3: Induced draft fan only				
Point A	28	25	24	30
B	8	10	3	12
C	24	33	29	37
Condition 4: Both fans on				
Point A	17	20	18	22
B	5	14	1	13
C	15	26	24	26

The results are averages of two tests on two different days. See individual test sheets in Appendix B for specific test data and weather data.

TABLE 3 FIELD TESTS OF THE DAMPERLESS, INSULATED FLUE WITH HIGH PRESSURE BURNER

			Depressurizations Measured That Created Spillage (Pa)			
			Cold Flue		Pre-heated Flue[2]	
House	Appliance Checked for Spillage	Appliance Burner Fan (ON/OFF)[1]	Before	Post-Retrofit	Before	Post-Retrofit[3]
Losier[4]	Furnace	OFF	5	5[5]		
	DHW	OFF	5	5[5]		
	Furnace	ON			5	1
	DHW	OFF			4	8
	Furnace	OFF			13	19
	DHW	ON			7	15
	Furnace	ON			9	3
	DHW	ON			7	6
Piercy	Boiler	OFF	2	6		
	Boiler	OFF			8[5]	15
	Boiler	ON			9[5]	14

(1) These tests were run with oil flow to the burners disconnected, so that the burner fan activated without the burner firing. This was done to limit the transient draft differences due to flue heating, which would require significant delays in measurement, until steady state conditions were reached.

(2) This is a hot flue, preheated for this test.

(3) For weather data see Appendices 5 and 6. Post-retrofit testing was conducted in warmer weather, with lower wind speeds.

(4) The Losier house has two appliances connected to the same flue. The tests were done in pairs for each case.

(5) Estimates only, based on Solsearch "Spillage" data increases. (See Appendix 5.)

5. CONCLUSIONS

The tests demonstrated that the remedial measures suggested for oil furnaces seem to be suitable ways to minimize combustion gas spillage, based on this limited field testing.

The induced draft fan, especially if used in conjunction with a solenoid delay on the burner, can reverse backdrafts and minimize spillage under any likely house depressurization. Downstream of the fan there may be some start-up spillage in flue pipe joints, unless these are properly sealed. There was no investigation of the effect of the fan on furnace/boiler burner performance.

The delayed action solenoid gives sufficient time for the burner fan to reverse an initial backdraft. It does not prevent spillage from the unintentional or intentional holes (eg. damper perimeter), although by better establishing proper flow in the chimney, it may reduce the duration of spillage. By a thorough sealing of the flue pipe and all connections, this spillage will be further reduced.

The damperless, insulated flue and high pressure burner does create an improved chimney draft and fewer holes for flue gas spillage to occur. The margin of improvement is not as great as with the induced draft fan and the cost of this retrofit is quite high. It seems to be a good option for homeowners with a furnace/boiler in good condition and a chimney in need of repair (or suffering from condensation problems).

While these remedial measures do reduce the range of house conditions under which spillage will occur, the effect of the measures on spillage duration is unknown. If further research shows that even short term spillage of oil-fired appliances can seriously degrade indoor air quality, spillage duration investigations must take place.

GLOSSARY

Barometric Damper is an air check valve located on the flue pipe between the furnace/boiler and the masonry flue. The barometric damper is usually of the same diameter as the flue pipe and will only let air into the flue. The damper is weighted with an adjustable weight, set to allow the damper to open if the chimney draft exceeds a certain positive number. The effect of the damper is to reduce the effect of draft variations at the combustion chamber. The barometric damper has no seals and is not airtight. Due to its location near corrosive gases, the damper frequently does not operate properly. Although barometric dampers are required by code, high pressure burners are often installed with damperless, insulated chimneys.

Backdraft occurs when the flow of the combustion gases is blocked or reversed from the usual direction up the chimney. Backdrafting usually occurs when the burner is off. If backdrafting occurs with the burner on, all the combustion products will vent into the house through air supply ports, the barometric damper and other combustion path holes.

Cold Flue is a flue that has not been used overnight and has reached a minimum steady state temperature. The actual flue temperature was not measured. Since the flue is an insulated metal asbestos flue, there is little thermal mass.

Cross-over is the "stall point" between positive and negative draft, when some smoke spills out or pulses in and out of the inspection hole, but direction is not definitely established. During testing, the determination of the cross-over point was a "judgement call" on the part of the tester, since the beginning of the spillage process was determined visually by a slight fluttering of the candle flame. For this series of tests, the tester estimated the point at which the flow fluctuated between equal periods of intake and exhaust through the inspection port.

Draft is the pressure differential measured in Pa between the furnace room and the interior of the flue pipe. The draft is usually positive due to chimney effect and will exhaust air from the furnace room to the outside. The draft may become negative if, for instance, the furnace room is under negative pressure relative to the exterior, due to competing exhaust appliances. In this case, gases from the interior of the combustion system may spill into the furnace room.

Hot Flue is a flue that has reached maximum steady state temperature by firing the burner for a minimum of 15 minutes prior to tests.

Negative Pressure is established when exhaust appliances in a tight home cause the interior house pressure to be negative relative to the outside pressure.

Puffing is temporary flow reversal or bursts of spillage occurring during ignition at appliance start-up.

Spillage is the flow of flue gases from burner, boiler and flue into the interior of the house. The flow was visually detected with a candle or smoke pencil. For the field trials, the tester waited for a definite exhaust of the gases (as opposed to cross-over) when determining the spillage point.

APPENDIX 1:

OPERATION OF A TYPICAL OIL-FIRED FURNACE

The start-up sequence begins when the controller provides electrical power to the blower fan and transformer. The oil pump is driven by the same motor as the fan; consequently, oil pressure builds simultaneously with air pressure. If a solenoid valve is installed, oil flow to the nozzle is delayed, allowing the fan and pump to develop maximum rpm. Combustion air is drawn in through an adjustable port on the burner and the air is mixed with the oil, which is vaporized at the nozzle. When the mixture is first ignited by the electrodes, the force of the ignition forces the barometric damper shut. Often a puff of smoke enters the room via various leakage points in the combustion path.

During the first few minutes of operation the combustion may be unsteady and the draft not well established. This will manifest itself with a closed barometric damper and puffs of exhaust emerging through leaks. Simultaneously, however, the oil burner fan is exhausting air from the furnace room, which is replaced with air from elsewhere in the house; in effect, purging the room. As the chimney is heated by the flue gases, the draft improves and the barometric damper opens, exhausting additional air from the house.

After several minutes of operation the chimney draft may develop 10 to 30 Pa, while negative pressures generated by competing exhaust appliances within the house might range from 3 to 7 Pa. When the burner stops after a 5 to 20 minute cycle, the chimney is still warm and air will continue to be exhausted from the room through the barometric damper and oil burner air ports, unless the burner is of the high pressure type. High pressure type burners are sometimes installed without barometric dampers and the model tested has a built-in damper on the air supply which closes automatically when the burner is not operating.

The typical oil-fired furnace system is designed to operate with a positive chimney draft (updraft). If positive draft is not present, spillage will occur, but positive flow up the chimney is usually maintained. Only under unusual circumstances, such as flue blockage, is chimney flow reversed, in which case black smoke will pour into the furnace room.

APPENDIX 2:

SELECTION AND DESIGN OF SIX REMEDIAL MEASURES

Based on consultation and feedback from John Haysom (Scanada) and Harry West, we considered the remedial measures further.

The list of remedial measures is reorganized as follows to more clearly connect the remedial action to the problem it is supposed to resolve. Note that group No. 1 are not really remedial actions, but diagnostic tools which may or may not be invoked prior to undertaking one of the remedial measures.

1. Alarm/Checklist/Test
2. Air supply to furnace room. Furnace room sealed from rest of house or sealed air intake (not, to our knowledge, available on oil-fired units.)
3. Prepurge cycle/solenoid valve.
4. Exhaust appliance priorization.
5. New insulated flue/with or without burner with damper.
6. Draft inducer fan.

Consultation and Review

1. Diagnostic Devices

1.1 **Alarms** Our knowledge of this item is based solely on the work of Sheltair. It is not a solution, but may be used as a diagnostic device if chimney failure is suspected.

If no other competing sources of dust or smoke exist near the furnace, then an ordinary smoke alarm may well be the best solution. The more expensive CO detector eliminates some false alarms, such as alarms caused by dust.

Guidelines need to be developed as to the proper location of alarms. Guidelines should be simple enough to follow by an ordinary homeowner who may choose to spend $10 to $30 on a self-installed detector prior to calling in a professional serviceman.

We note that, in our experience, fire alarms are frequently disconnected if they are seen to give "false" alarms, such as being set off by a toaster. It should be made clear to homeowners that if the alarm sounds once, the next step is a check by a qualified technician. (Checklist)

1.2 Checklist The checklist would be the next step if an alarm or other evidence did show the presence of backdraft problems. We have reviewed the checklist proposed by Sheltair and agree that this checklist should be able to be performed by a technician without sophisticated equipment such as a door fan. Our firm has had simple checklists and tests with smoke pencils in previous backdraft measurements. It is our opinion that additional equipment, such as manometers and door fans, serves to quantitate the problems but does not assist significantly in determining the nature of the problems.

1.3 Test We have performed tests with sensitive manometers and door fans to quantify the nature of backdraft problems and the spill-over points for various competing appliances. These instruments are excellent research tools, but do not add significantly to the diagnosis of the problems. The tools are extremely sensitive to variations in the weather.

2. Separate Air Supply

Our knowledge of this subject is through installing separate air supplies in five projects where previous airsealing resulted in backdrafting (as measured by Sheltair's method), documents presented in this project, and conversations with Harry West.

Two methods of providing a separate air supply are:

2.1 Sealed supply, a direct duct from the exterior directly connected to the burner. This method is available for condensing gas boilers but is not, to our knowledge, available for oil burners. The theoretical advantage is the total isolation from any competing appliance. Disadvantages may include a great variation in the temperature of the air supply.

2.2 Air supply to sealed furnace room. The air supply can be (a) a window or other direct opening or (b) a duct with cold air lock or motorized damper. A 5" or 6" diameter opening prevented backdrafting as per the Sheltair test in our test houses. NBC however requires 3.3 mm^2/watt (NBC sec. 6.2.5.1.(2)). For a typical furnace with a 1 gallon nozzle, this translates to 150 sq. inches, substantially bigger than air supplies typically provided.

Undercut furnace room doors and other air leaks to the remainder of the house may hinder the effectiveness of the air supply in the presence of other competing appliances. Regular airsealing techniques can, however, overcome this problem. If a competing appliance such as a dryer is located within the room the supply must be sized to handle both appliances.

Even with a U-shaped cold air lock, homeowners report cold drafts from air supply when the burner is not in use. Local contractors have manufactured motorized dampers, which open only when the furnace is on. The damper can be wired "fail safe", with a spring loaded, normally open damper, switched to allow burner operation only when open. The cost is approximately $100.

Bare metal air supply ducts will typically cause condenstion. Harry West reports successfully avoiding this by insulating ducts with 1" foil-covered glass fibre batts.

3. Prepurge Cycle/Solenoid Valve

Discussed in detail in previously submitted paper, this low cost solution offers in addition to reduced backdrafting a bonus in a cleaner heat exchanger and resulting greater efficiencies and fuel savings.

4. Exhaust Appliance Prioritization

One successful prioritization (Jennair Stove disabling furnace, when operating) has been reported by Sheltair. It is a low cost solution, but adds to the technical complexity of the house. The unsuspecting furnace repairman may not realize that a malfunctioning furnace may be connected to the stove and one can imagine a situation where the homeowner leaves the house with the Jennair on to clear the air in the house, and returns much later to find the pipes frozen.

5. New Insulated Flue

This remedial measure has been documented by Harry West in "Stainless Steel Liners" Standards and Installation manual. A typical installation is done in conjunction with the installation of a high pressure burner with an integral damper on the air supply and elimination of the barometric damper. The reduced opening, insulated stainless steel flue reduces backdraft due to the thermal mass of an oversize masonry chimney. The safety of any deteriorated flue is also drastically increased. A vent cap reduces backdraft due to wind gusts.

The burner also has an integral delayed action solenoid valve. The elimination of the barometric damper and the air supply valve not only reduces the backdrafting potential but also eliminates the standby stack losses. The installation manual of the burners does not specify the removal of the barometric damper, and most installers here on P.E.I. leave the barometric dampers on.

6. Draft Inducing Fan

Located after the appliance, before or in the chimney, the draft inducing fan boosts the draft of the chimney. The use of this device is common in industrial applications, but is rarely used residentially. Harry West feels that the increased draft may potentially damage the fire box. The cost of the device is fairly high ($500 range). The device does not really solve the cause of any backdrafting problems, and may indeed cause other appliances to backdraft. Technical complexity, noise and maintenance costs are increased. Located in a corrosive atmosphere, such a device can be expected to have a shorter lifespan.

Harry West reports that he eliminates dampers and employs reduced flue sizes under a section of the B139 Code, allowing qualified consultants to take such steps. This leaves the liability squarely on the installer. It would be desirable to get direct code approval for removal of the backdraft damper if this is going to be a commonly recommended remedial measure. There is also the question of boiler warranty, when reducing the flue size below the size recommended by the boiler manufacturer.

On the question of liability, Skip Hayden comments that in the course of the widely used burner conversion program here on P.E.I., where thousands of burner/boilers were equipped with retention heads, the retrofits were done without obtaining prior approval from boiler manufacturers or CSA approvals for specific system combinations.

Plan for Insulated Flues

Location: Two houses with backdraft problems will be selected. Both will have previously installed Riello burners. One house is to be new and relatively airtight. The other house is to be old and relatively leaky, with backdraft likely to be due to an oversized chimney.

Testing: Tests 1, 2, 3 and 4 will be conducted on the furnace/chimney prior to and after installation of the new insulated chimney. A "cold" chimney test will offer a several-hour cooling period.

Installation: A contractor familiar with the installation of chimney liners will be engaged to install liners as per the manual. Henry West has agreed to visit the sites during installation. His time will be shared between: technical transfer (his insulated chimney system is not well known in P.E.I.) and discussing the chimney test program.

Cost: Harry West will provide flue materials free of charge. The project will be charged the direct cost of employing a mason, estimated at $300 to $400 per house.

Discussion: Since submitting the original research paper, additional input from other team members has initiated additional topics to be considered.

The objectives of any remedial measure are:

1. to reduce or eliminate chance of backdrafting
2. to utilize existing equipment and servicemen if possible
3. to be inexpensive, or if expensive, offer other benefits which justify the greater cost
4. not to add to the complexity or service requirements of the mechanical systems of the house.

Re 1. Alarms and checklists are clearly diagnostic tools, not a solution, and therefore do not fall within our task. We suggest however that conventional smoke alarms be tested out as a warning device in a few of the houses where the spot test may indicate problems.

Re 2. Separate air supply is an excellent remedy. To be tested and developed by SRC.

Re 3. Prepurge cycle/solenoid valve. In houses previously tested, the backdrafting problems were all overcome by the burner, after a short period. The device is easily installed and is in fact standard on some equipment. The device is inexpensive and results in cleaner operation and fuel savings. Clearly a superior solution to be tested.

Re 4. Prioritization. Although an inexpensive measure, this measure adds to the complexity of the system. Backdrafting problems may be resolved, but new problems, such as freeze-up, may be added. Not recommended as a measure.

Re 5. Insulated flue. The high cost is the only drawback of this measure. Where a deteriorated flue justifies work on the chimney, this is a recommended solution. Particularly suitable for the many century old flues of P.E.I. At Harry West's suggestion, this measure will be tested in two locations. The measure not only improves draft but greatly increases the general safety of the flue.

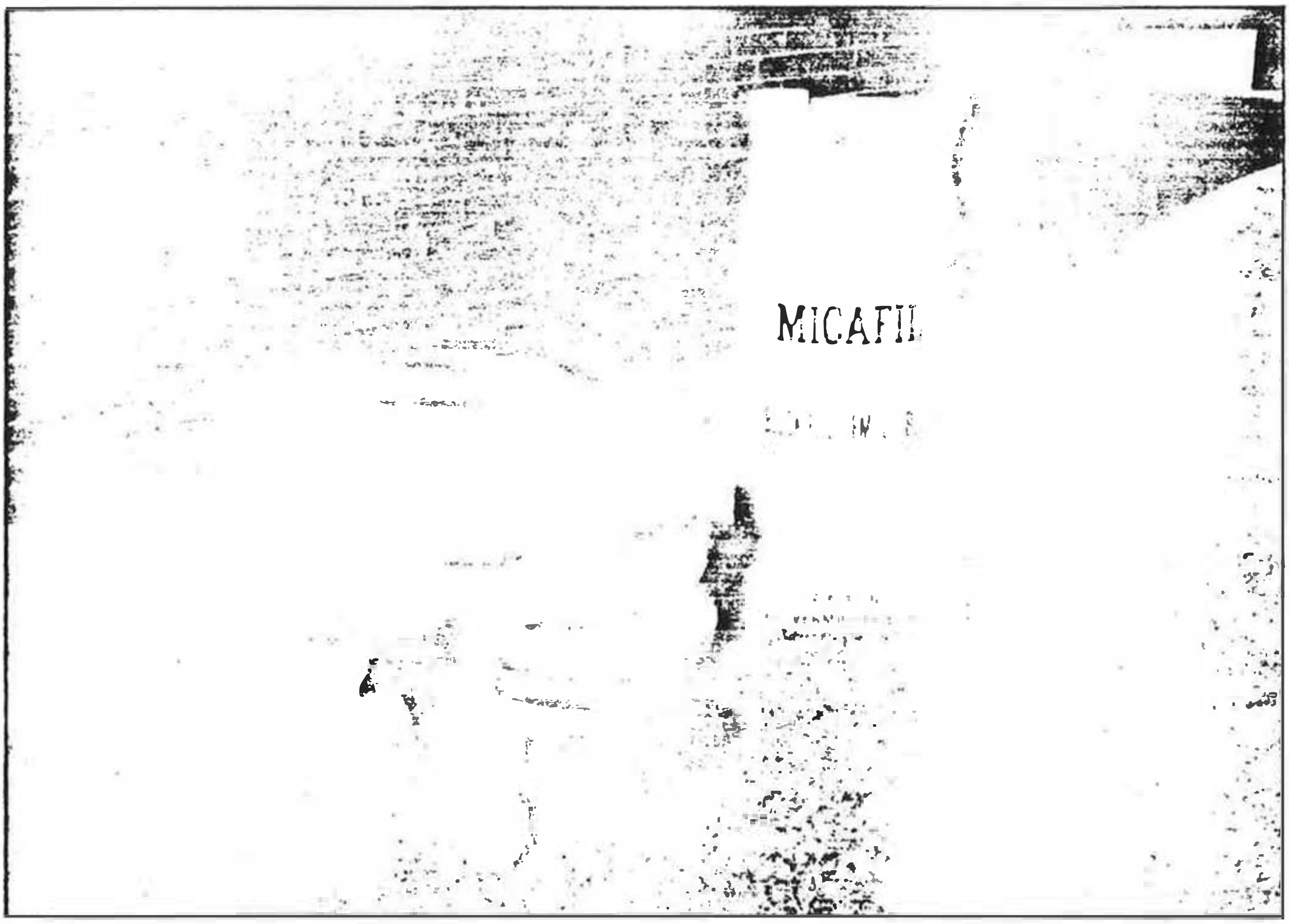
Re 6. Draft assistance. As already outlined previously, a draft assistance fan will be tested at Holland College. With a relatively high cost, plus added complexity, this is not a recommended measure, but testing will serve as a useful "benchmark" against which to test the obtainable pressure of oil burners.

APPENDIX 3:

SPECIFICATIONS OF EQUIPMENT USED IN TESTING

STAINLESS STEEL LINERS

ANOTHER ECONO SAVERS PRODUCT FROM ECONO TECH™



STANDARDS AND INSTALLATION MANUAL

TABLE #1

Combustion Products Plus Barometric Damper Dilution

% EXCESS AIR	10	15	25	35	50	65	85	110
*% O_2	2	3.5	4.5	6.5	7.5	9	10.5	11.5
*CO_2	14	13	12	11	10	9	8	7

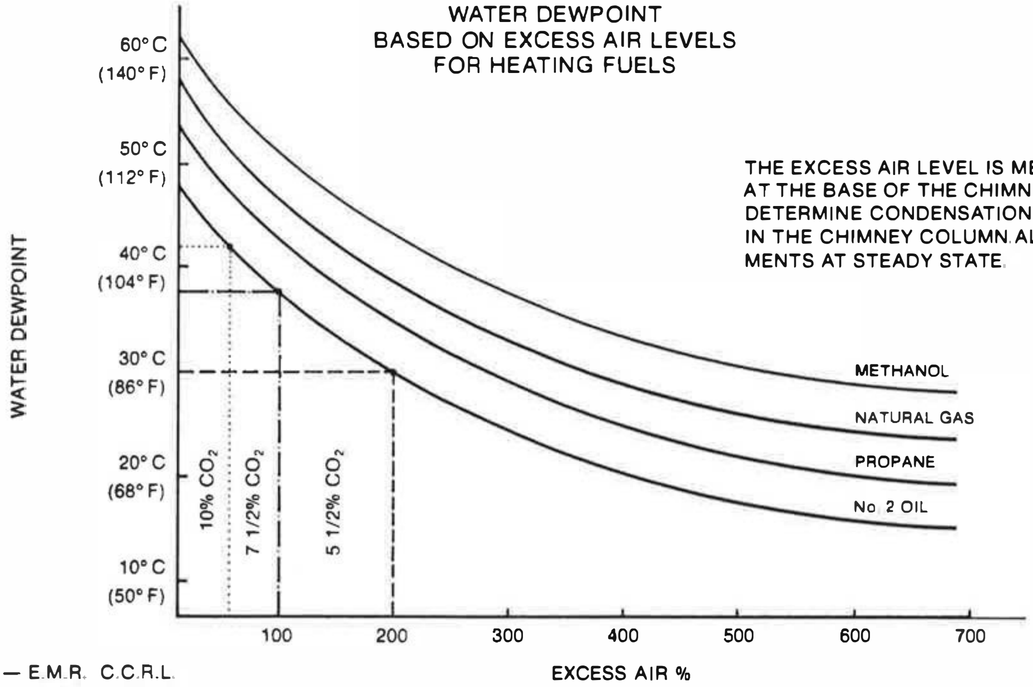
FIRING RATE U.S.G.P.H.	CUBIC FEET PER MINUTE							
1.10	25.5	27.1	29.5	32.2	35.4	39.1	43.6	49.5
1.00	24.3	25.8	28.1	30.7	33.7	37.1	41.5	47.2
.85	20.6	21.9	23.9	26.1	28.6	31.6	35.3	40.1
.75	18.2	19.4	21.0	23.0	25.3	27.9	31.2	35.4
.65	15.8	16.8	18.2	19.9	21.9	24.8	27.0	30.6
.60	14.5	15.5	16.8	18.4	20.2	22.3	24.9	28.3
.50	12.1	12.9	14.0	15.3	16.9	18.6	20.8	23.9

*Measured at Chimney Base

Table #1 shows volumetic flow rates of gas at 15.5° C (60° F) associated with various excess air levels.

Chimney Construction

A typical chimney in North America is a brick/block masonry construction with a standard chimney tile liner down to the clean-out. The clean-out is normally 18" to 24" below the inlet of the heating appliance. In some construction only two clay tiles were used top and bottom. This resulted in two courses of brick to make the chimney perimeter between the two tiles.



HAYDEN — E.M.R. C.C.R.L.

Conditions (cont'd.)

Volume of Flue Gases = 30.3 cu. ft. per minute

Weight of Flue Gases = 30.3 x .075 = 2.28

Heat Content
(2.28 weight) x (60 Time) x (275°F Temp.) x (0.24)
= 9,028 B.T.U.H.

*Absorption rate of flue B.T.U.H. at 25°F
(65.3 sq. ft. area) x (199°F average temperature) x (1.0 coefficient)
= 12,995 B.T.U.H.

*Absorption rate of flue B.T.U.H. at —3°F
(65.3 sq. ft. area) x (199°F) x (2.0 coefficient)
= 25,592 B.T.U.H.

*N.B. The ability of the chimney to absorb all the heat is self evident but the centre core of flow does not come in contact with the tile liner. 100% condensation does not happen.

The variables that cause condensation:

(1) Time delay to achieve steady state, up to 5 minutes.

(2) Appliances do not cycle for 60 minute burn time for maximum B.T.U.H. input.

(3) High relative humidity of the dilution air changes the dewpoint upwards from that calculated with dry air.

(4) The flue can absorb more latent heat than the heating appliance can produce. Cold outdoor temperatures with long off cycles normally produce pulsations on start.

Case

Installation of 5" Ø stainless steel liner insulated between the liner and the existing tile liner.

Chimney Height	8.5M	28'
Temperature at Breach	287.7°C	550°F
CO_2 at Breach	13-1/2%	
Temperature at Base of Chimney	123.8°C	255°F
CO_2 at Base	6-1/2%	
Flue gas exit temperatures Centre of Flow 8" below exit	96.1°C	205°F
Average temperature of flue	230°F	

Heat Loss or Absorption Rate

Perimeter = 15.7"
Height = 28'
Area = 15.7 x (28x12) ÷ 144 = 36.3 sq. ft.

Total B.T.U.H. Loss

Square ft. of surface area x average flue gas temperature x coefficient of heat transfer = Loss

36.3 sq. ft. x 230° x 0.4 = 333.96 B.T.U.H.

The use of a stainless steel chimney liner will eliminate or control condensation problems, establish draft almost instantaneously and provide a designed venting system for increased efficiency during operation.

ECONO TECH™ PRODUCTS

Z Flex Stainless Steel Liners

MATERIAL: The material used for production of Z Flex Liner is a special 316 alloy 0.005" thick. U.L. listed.

CONSTRUCTION: Spiral look continuous seam.

TESTING: A series of performance tests were completed by Warnock Hersey, an independent testing lab. The tests were conducted under the guidelines: "Underwriters Laboratory Proposed Requirements Liners for Masonry Chimneys Venting Oil and Gas Fired Appliances". The test file is #FL 200-290-040 and the tests were conducted under requirements outlined in ULC-S629-M1981 which is requirement for **650° C** factory built insulated chimneys.

Additional tests were conducted for:

CORROSION: Severe sulphurous acid bath ULC S 609 standard for L vents.

STRENGTH: A 200 pound force was exerted on a section of liner suspended from a forklift truck.

FLEXIBILITY: Liner was bent around a wooden form of 17.5" radius through 180° for three separate applications. No separation or collapse.

TORSION: A sample liner suspended from a beam in a fixed position was rotated 180° clockwise and then returned to its original position. This test was repeated three times; no separation was observed.

ABRASION: An eight foot long sample liner of 5" nominal was drawn through an unlined masonry chimney ten times. The flue was 7 1/4" x 7 1/4". The liner withstood the test without showing any joint separation, rupture, or visually observable damage which would cause the material to be unsuitable for its intended use.

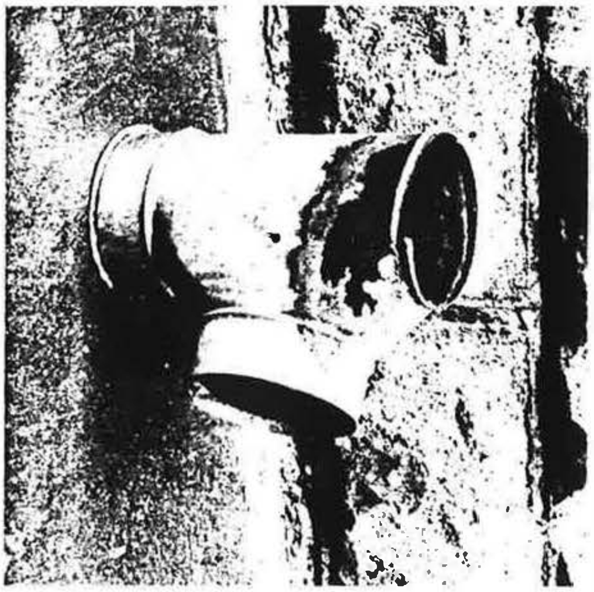
TIGHTNESS TEST: Samples of the liner were subjected to a tightness test after the temperature, strength, flexibility, torsion and abrasions tests were completed. Both ends of the sample liners were plugged with wooden plugs and sealed with silicone sealant. Each sample was pressurized to 0.5" water gauge using compressed air. The pressure was monitored to a minimum leakage rate of 0.42 cubic feet per hour. After all previous tests the samples all passed a tightness test or leakage rate less than the detectable flow rate. The liner was subjected to additional tests for puncture rate, liquid penetration and a brush sweep test for cleaning.

The conclusions by K. S. Chan, P. Eng., Metallurgical Engineer, Physical Testing Services for Warnock Hersey Professional Services Ltd.:

"The chimney liners of various nominal diameters complied with the proposed requirements for flexible liners for masonry chimneys for venting oil and gas fired appliances issued by ULC and dated August 31, 1982.

The liner, when installed with the proper care and following the instruction procedures, will provide the consumer with a safe, highly efficient venting system."

ECONO TECH™ PRODUCTS — *STAINLESS STEEL LINERS*



The vent chimney adapter is seriously corroded after only three years. The opening was causing the excessive dilution of the flue gases and the potential for severe leakage is self-evident if the chimney becomes plugged.

Outside the residence, the chimney condensation has migrated over a wide area of the brick work — a tell-tale sign of a potential problem by visual observation.

A close-up of the damage starting over the window lintel.

Close-up of the chimney base.

Note: There is no metal thimble in the opening to accept the vent pipe.

The Liner Kit: 316 stainless U.L. listed and Warnock Hersey tested. The kit shown is a 25' 5" diameter unit. The actual kit length required on our installation was 18'. There will be 20' kits available for future installations.

The cap in the foreground is a special aerocowl cap which we have evaluated with the permission of the Ministry of Commercial and Consumer Relations — Fuel Safety Branch. The units you will receive will have the aerocowl U.L. listed cap for installation.

Industrial Vermiculite

The back fill material to provide easy installation of insulating material is a block fill vermiculite. The block fill insulation must be waterproof type that will not become water laden by osmosis. Wet insulation surrounding a round liner, if low temperature causes freezing, will destroy the chimney. The use of insulating material improves the performance of your vent system by decreasing the temperature drop in the vent. The use of insulation will also prolong the life of the liner by maintaining the flue gas temperatures above the dew point for all applications properly sized. No condensation, no damage.

The enlarged opening.

Ensure that if the open webbs of the blocks are visible, plug the openings to stop the insulation from leaking into the block foundation.

Chimney contractor uses strong cord to attach to the plug. The plug is used to lead the liner down the existing chimney and around any offsets that may be encountered.

Special Note:

The normal installation of this liner will be easy with offsets of up to 45° angles. If the chimney offset is over 45°, the outside wall will have to be opened to allow the offset installation of the liner. The use of extreme force to pull the liner around a severe offset will only crush the liner, choke the free area and cause you further problems plus expense. Don't risk a severe offset with five inch diameter liner unless it is a 12" x 12" tile.

ECONO TECH™ PRODUCTS — *STAINLESS STEEL LINERS*

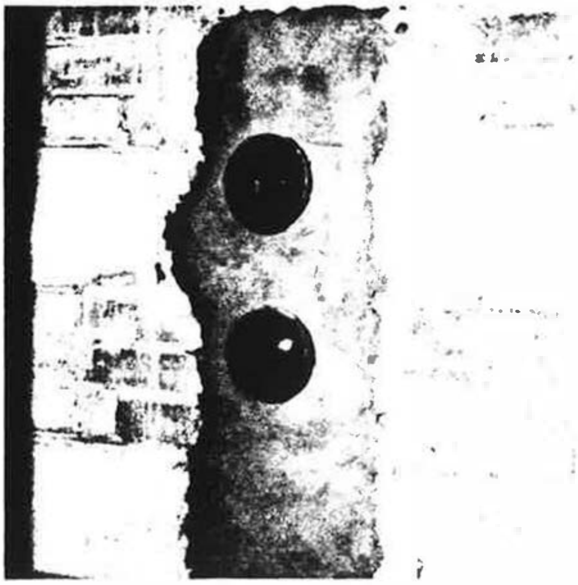
Slowly feed the liner into the masonry chimney.

Feeding the liner with the rope being pulled down at basement level from the enlarged opening.

The liner is now in position at the basement opening.

Fiberglass insulation is now packed at the rear and sides of the double base tee. This will help centre the double base tee in the cavity.

Close-up of the double base tee in place. To keep mortar out of the vent during rebricking and plastering of the opening, a fiberglass plug is useful.



The Finished Opening

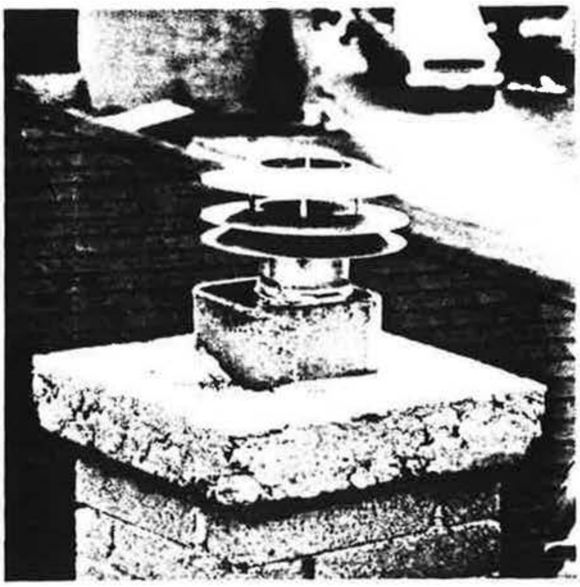
Bricks should be laid and then mortar applied as a plaster coat to make the wall smooth.

Cutting excess liner material using either a utility knife or a set of pipe shears. Cut the liner a minimum 8" to 12" above the tile liner. The exact height required can be determined later when the aerocowl is being installed.

The Final Cut

Because the material is spiral locked, very sharp edges are produced during cutting. Use care or a severe laceration may occur. If you can work with gloves, do so.

Install stainless steel adapter for mounting aerocowl on liner.



Now start placing the special mortar.

Trowel up a shoulder.

The finished product.

The mortar should be a minimum of 3" of depth inside the tile flue and raised above the tile flue to form a rain collar sloping from the liner to the flue tile. Ensure that the mortar is smooth, packed and sloped.

The use of *"approved"* stainless steel liner material is a must to provide the longevity and safety that is required. With a venting system, the proper care taken during the installation procedure will also ensure proper efficient operation of the heating appliance connected to the liner.

ACKNOWLEDGEMENT

The continuing search for answers to the problems with high efficiency equipment venting systems was long, but in the end, rewarding.

Various people in their daily job functions provided information that kept the search for the right answers on track.

A special thanks to C. S. "Cliff" James, of Esso Petroleum Canada, who provided technical answers from a storehouse of information and turned up with the solutions for sizing, friction, loss, and condensation plus the rates of thermal loss that we were encountering in the field tests.

H. R. West
Esso Petroleum Canada
September, 1985

ELECTRICAL WIRING

Dashed Lines Represent 24 Volt Circuit.
Solid Lines Represent 115 Volt Circuit Unless Noted Otherwise.

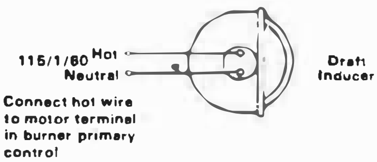


DIAGRAM NO. 1
MOTOR DRIVEN OIL OR GAS BURNER
Fan Prover Switch Omitted

- Burner and inducer start simultaneously
- Diagram applicable when total of amperes for burner motor, transformer, valve, etc., plus inducer motor does not exceed amperage rating of burner primary control

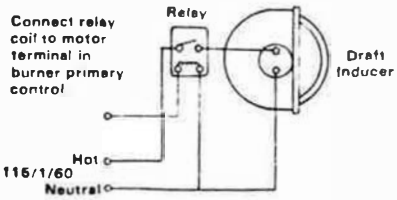


DIAGRAM NO. 2
MOTOR DRIVEN OIL OR GAS BURNER
Fan Prover Switch Omitted

- Burner and inducer start simultaneously
- Diagram applicable when total of amperes for burner motor, transformer, valve, etc., plus inducer motor exceeds amperage rating of burner primary control

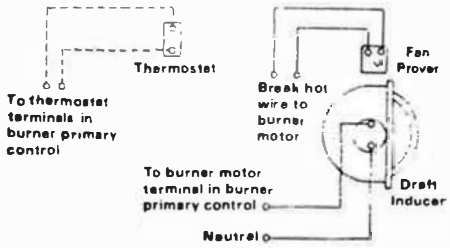


DIAGRAM NO. 3
OIL BURNER WITHOUT OIL VALVE

- Burner fires after inducer operation is proved
- Diagram applicable when total of amperes for burner motor, transformer, valve, etc., plus inducer motor does not exceed amperage rating of burner primary control

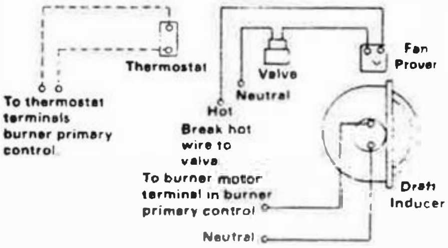


DIAGRAM NO. 4
MOTOR DRIVEN GAS BURNER OR OIL BURNER WITH VALVE

- Burner fires after inducer operation is proved
- Diagram applicable when total of ampers for burner motor, transformer, valve, etc., plus inducer motor does not exceed amperage rating of burner primary control

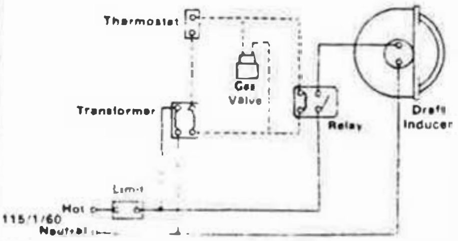


DIAGRAM NO. 5
ATMOSPHERIC GAS BURNER
24 VOLT CONTROL
Fan Prover Switch Omitted

- Burner and inducer start simultaneously

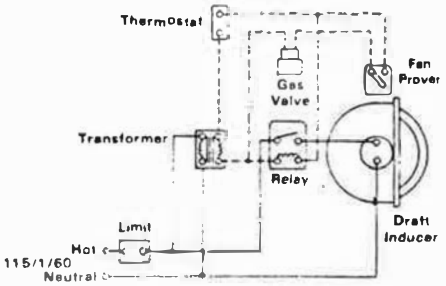


DIAGRAM NO. 6
ATMOSPHERIC GAS BURNER
24 Volt Control

- Burner fires after inducer operation is proved

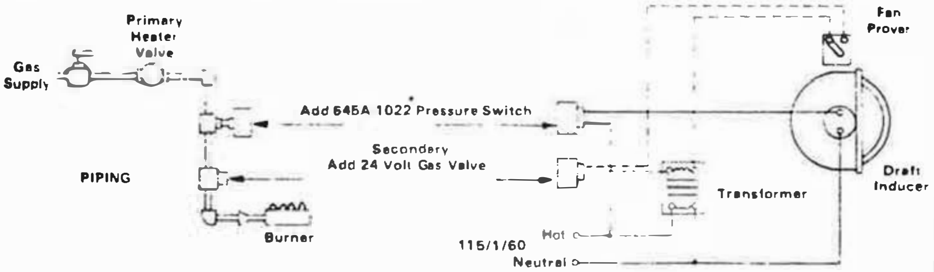


DIAGRAM NO. 7
NON-ELECTRIC OR POWERPILE CONTROL WATER HEATER

- When control on water heater calls for heat, gas pressure is established up to new pressure switch and as far as new secondary gas valve. Gas pressure switch starts inducer.
- When inducer operation is proved, fan prover opens secondary gas valve, allowing gas flow to burner.

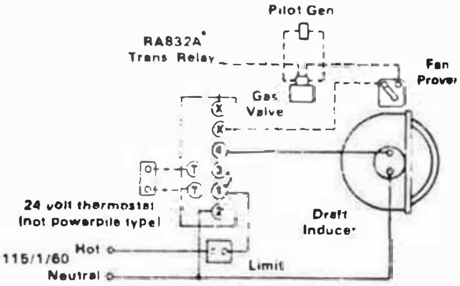
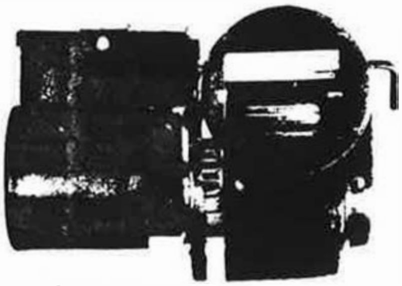


DIAGRAM NO. 8
POWERPILE TYPE GAS BURNER
Fan Prover Switch Omitted

- Burner and inducer start simultaneously

OTHER TJERNLUND PRODUCTS



HS INDUCERS

Special design for gas and oil-fired applications. High pressure permits substantial reduction in flue size

DUCT BOOSTER®

Increases flow in warm or cold air branch ducts.

UL
LISTED

TJERNLUND
PRODUCTS, INC.

OWNERS INSTRUCTIONS

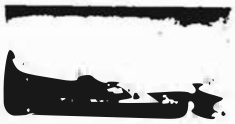
THESE INSTRUCTIONS MUST REMAIN WITH EQUIPMENT

DO NOT DESTROY

AUTO-DRAFT® INDUCERS

SIMPLE INSTALLATION

1. CUT SLOT IN PIPE



(Template furnished)

2. INSERT INDUCER

3. INSTALL BANDS

(Model DJ2 fastened with screws)

NOTE Inducer is shown tilted in above pictures to show slot. Actual installation must have shaft horizontal.

INSTALLATION AND SERVICE INFORMATION

MOUNTING—The draft inducer may be mounted on vertical horizontal or inclined smokepipe. **NOTE: This inducer must not be used in sidewall venting applications. Sidewall venting requires the use of a Tjernlund HS-Series inducer.** If used on a horizontal smokepipe, mount inducer on bottom of pipe, not on top, to avoid creating a heat trap in inducer. Cut rectangular slot in pipe and fasten in place with mounting bands provided (the Model DJ2 does not require bands—use mounting screws provided). Select a position between barometric draft regulator or diverter and the chimney, locating the inducer as near chimney as possible. The motor shaft must be level and horizontal to avoid excessive wear of bearings. Do not use "bullhead" tees when connecting two smokepipes together. When tees are necessary, connect at 45° angle or less. If change in smokepipe size is required, use tapered increaser or reducer.

DRAFT CONTROL—The degree of the induced draft provided by the Auto-Draft inducer can be varied by the exclusive Vari-Draft Control. Moving the lever of the Vari-Draft while observing readings with a draft gauge will allow setting for maximum draft required.

Oil burning installations and gas-fired units without a draft hood should include a barometric draft regulator. This should be adjusted to barely close when conditions require maximum effect of the draft induced. The barometric control will then open to regulate draft as external conditions change to lessen effect required by the inducer.

The Model DJ2 does not have lever adjustment of Vari-Draft, but the inducer can be removed from the smokepipe and the Vari-Draft blade bent by hand.

When several heaters, or a single heater with more than one smoke outlet are installed, it is possible that draft may vary widely at each outlet. If this condition exists, restrictions such as baffles or locked dampers may be required in outlets where highest draft occurs. Restricting these outlets will increase draft in remaining connections.

FAN PROVER (Recommended) - Instructions for mounting Prover are packed with each prover.

The Tjernlund Fan Prover has been designed to monitor the pressure within the fan housing only. A motor or wheel failure will decrease housing pressure and actuate the pressure switch thus preventing combustion.

The Fan Prover is not a safety control designed to ensure proper draft or to indicate chimney failure. It is the responsibility of the end user to properly maintain both the combustion equipment and its chimney or vent. Yearly maintenance and inspection should be conducted by qualified service personnel. Failure to follow such maintenance and inspection procedures may result in generation of toxic carbon monoxide gas.

SERVICE—Specific instructions cannot be made concerning frequency of lubrication. Normal usage will require oiling no more than twice a year. **No more than 3 drops of S.A.E. 20 oil should be used.** Oil holes or lances are provided at front and rear faces of motor. Units with sealed ball bearings will normally operate for years without repacking of bearings.

Belts on belt driven inducers should be checked and adjusted at least once a year. Replace worn belts immediately. On Model HD two belts are used and when either belt needs replacement, a matched pair of new belts must be installed.

Misadjusted and inefficient burning of firing device may cause soot and hard carbon buildup on inducer wheel. This can result in an unbalanced wheel and damage may occur to shaft and bearings as well as reduce the efficiency of the inducer. Inspect inducer periodically and clean if necessary. Correct burner operation to cleanup fire.

ELECTRICAL WIRING

Dashed Lines Represent 24 Volt Circuit.
Solid Lines Represent 115 Volt Circuit Unless Noted Otherwise.

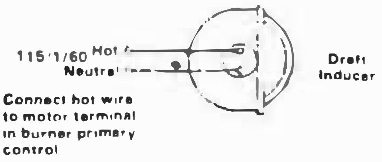


DIAGRAM NO. 1
MOTOR DRIVEN OIL OR GAS BURNER
Fan Prover Switch Omitted

- Burner and inducer start simultaneously
- Diagram applicable when total of amperes for burner motor, transformer, valve, etc. plus inducer motor does not exceed amperage rating of burner primary control.

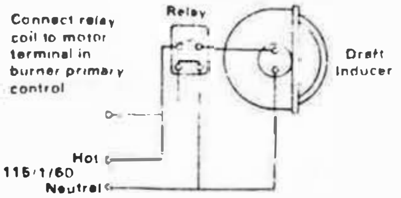


DIAGRAM NO. 2
MOTOR DRIVEN OIL OR GAS BURNER
Fan Prover Switch Omitted

- Burner and inducer start simultaneously
- Diagram applicable when total of amperes for burner motor, transformer, valve, etc. plus inducer motor exceeds amperage rating of burner primary control

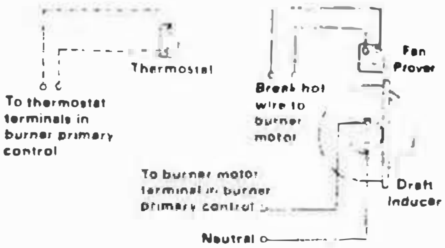


DIAGRAM NO. 3
OIL BURNER WITHOUT OIL VALVE

- Burner fires after inducer operation is proved
- Diagram applicable when total of amperes for burner motor, transformer, valve, etc. plus inducer motor does not exceed amperage rating of burner primary control

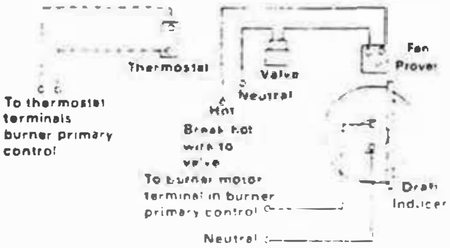


DIAGRAM NO. 4
MOTOR DRIVEN GAS BURNER OR OIL BURNER WITH VALVE

- Burner fires after inducer operation is proved
- Diagram applicable when total of amperes for burner motor, transformer, valve, etc. plus inducer motor does not exceed amperage rating of burner primary control

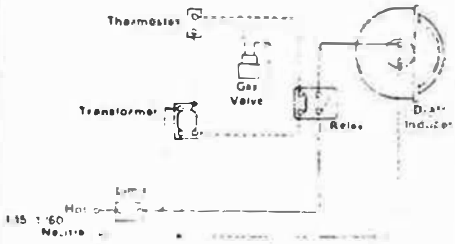


DIAGRAM NO. 5
ATMOSPHERIC GAS BURNER
24 VOLT CONTROL
Fan Prover Switch Omitted

- Burner and inducer start simultaneously

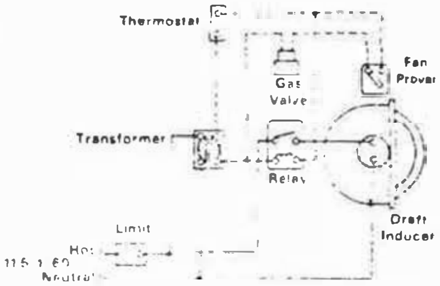


DIAGRAM NO. 6
ATMOSPHERIC GAS BURNER
24 Volt Control

- Burner fires after inducer operation is proved

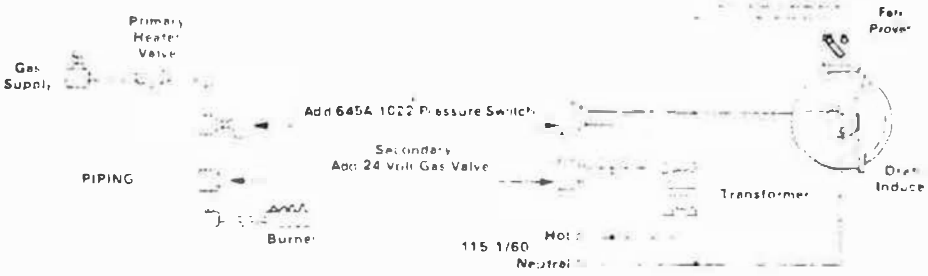


DIAGRAM NO. 7
NON-ELECTRIC OR POWERPILE CONTROL WATER HEATER

- When control on water heater calls for heat, gas pressure is established up to new pressure switch and as far as new secondary gas valve. Gas pressure switch starts inducer.
- When inducer operation is proved, fan prover opens secondary gas valve allowing gas flow to burner.

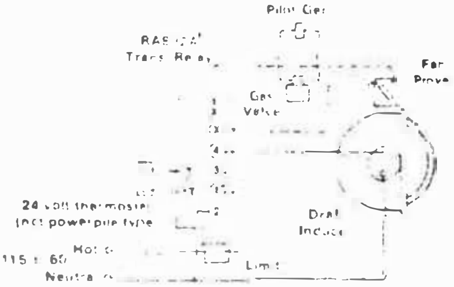
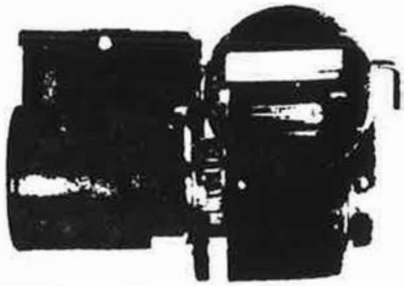


DIAGRAM NO. 8
POWERPILE TYPE GAS BURNER
Fan Prover Switch Omitted

- Burner and inducer start simultaneously

OTHER TJERNLUND PRODUCTS



HS INDUCERS

Special design for gas and oil-fired applications. High pressure permits substantial reduction in flue size

DUCT BOOSTER

Increases flow in warm or cold air branch ducts

UL
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ELECTRICAL WIRING cont.

Dashed Lines Represent 24 Volt Circuit
Solid Lines Represent 115 Volt Circuit Unless Noted Otherwise

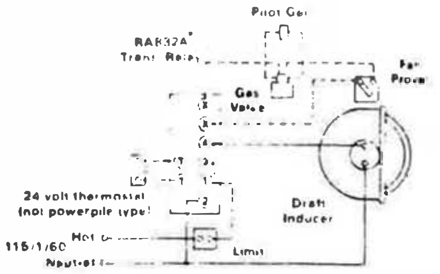


DIAGRAM NO. 9
GAS BURNER WITH POWERPILE

- Burner fires after inducer operation is proved

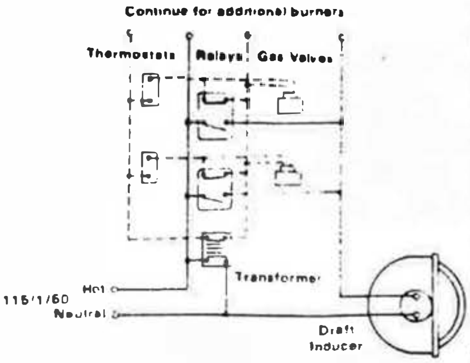


DIAGRAM NO. 10
MULTIPLE ATMOSPHERIC GAS BURNERS
Fan Prover Omitted

- Any thermostat will start draft inducer
- Corresponding burner will fire simultaneously

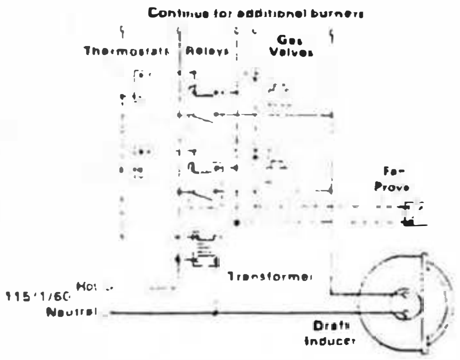


DIAGRAM NO. 11
MULTIPLE ATMOSPHERIC GAS BURNERS

- Any thermostat will start draft inducer
- Corresponding burner will fire after inducer operation is proved

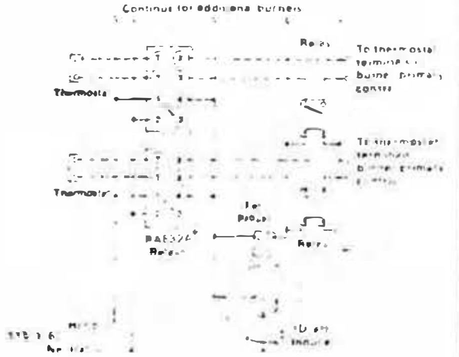


DIAGRAM NO. 12
MULTIPLE OIL BURNERS — Inducer Motor 7 Amps or Less

- Any thermostat will start draft inducer
- Corresponding burner will start after inducer operation is proven
- Diagram applicable when inducer motor is single phase and 7 amps or less

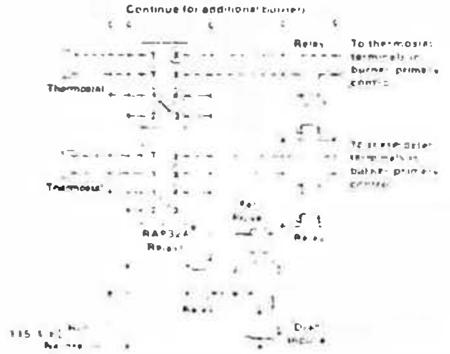


DIAGRAM NO. 13
MULTIPLE OIL BURNERS — Inducer Motor Over 7 Amps

- Any thermostat will start inducer
- Corresponding burner will start after inducer operation is proven
- Diagram applicable when inducer motor is single phase and over 7 amps

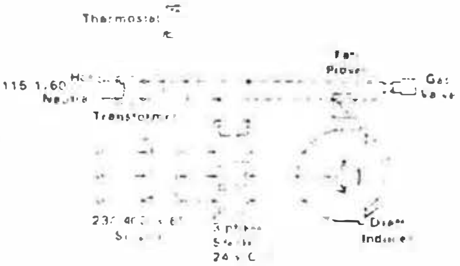


DIAGRAM NO. 14
GAS BURNER
24 Volt Control With Model HD Draft Inducer

- Burner fires after inducer operation is proved

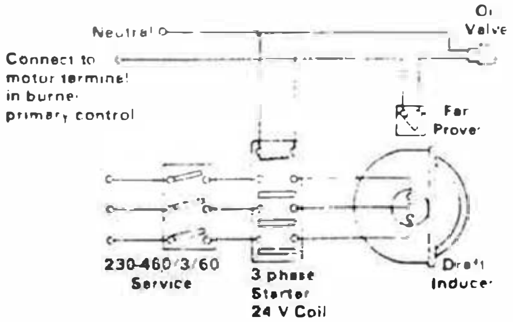


DIAGRAM NO. 15
OIL BURNER WITH MODEL HD DRAFT INDUCER

- Burner fires after operation is proved

*Mpls. Honeywell Model No.

TJERNLUND PRODUCTS, INC.

1620 TERRACE DRIVE, ST. PAUL, MINNESOTA 55113
(612) ~~636-7500~~
426-2993

TJERNLUND LIMITED ONE YEAR WARRANTY

Tjernlund Products, Inc. warrants to the original purchaser of this product that the product will be free from defects due to faulty material or workmanship for a period of one (1) year from the date of original purchase or delivery to the original purchaser, whichever is earlier. Remedies under this warranty are limited to repairing or replacing any product which shall, within the above stated warranty period, be returned to Tjernlund Products, Inc. at the address listed below, postage prepaid. *THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF AND TJERNLUND PRODUCTS, INC. EXPRESSLY DISCLAIMS LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING FROM THE USE OF THIS PRODUCT. THIS WARRANTY IS IN LIEU OF ALL OTHER EXPRESS WARRANTIES AND NO AGENT IS AUTHORIZED TO ASSUME FOR US ANY LIABILITY ADDITIONAL TO THOSE SET FORTH IN THIS LIMITED WARRANTY. IMPLIED WARRANTIES ARE LIMITED TO THE STATED DURATION OF THIS LIMITED WARRANTY.*

Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. In addition, some states do not allow the exclusion or limitation of incidental or consequential damages, so that the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which may vary from state to state.

Send all inquiries or products under this warranty to Tjernlund Products, Inc., 1620 Terrace Drive, Saint Paul, Minnesota 55113 (612) 636-7500.

DU PLASTIC PORTABLE GAGES

Dwyer solid plastic portable manometers are precision instruments in inclined and vertical (well-type) styles for the measurement of static pressure, vacuum or differential pressure.

To assure the accuracy required in instruments of this type, all machining of bores and wells is to the highest standards of precision backed by Dwyer's years of experience in the fabrication of acrylic instruments.

Design and Service Features

- **1" Thick Acrylic Plastic Body** is a solid block, virtually unbreakable, stable and free of the danger of distortion.
- **Drilled Bore Accurate to ± .0002"** are permanently free of bends or crooks, will not require recalibration because of distortion.
- **Selected Gage Oil** with high wetability characteristics forms a consistent, well shaped meniscus for easy readability.
- **Adjustable Reflective Chrome Finish Scales** with thumbscrew locking for easy zeroing.
- **Parallax-Free Reading** for maximum accuracy and consistency is achieved by simply aligning the meniscus with its image reflected in the polished aluminum scale.
- **Screw Type Leveling Adjustment** for inclined style gages provides rapid and accurate leveling with reference to integral sensitive ground glass bubble level.
- **Furnished Complete** with accessories and plastic carrying case.

Fig. 4-1. No. 100.5 solid plastic portable gage with .10-0-1.0" W.C. range. Shown with carrying case and standard accessories.

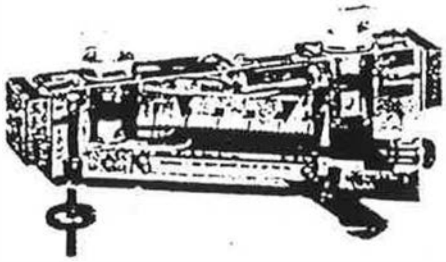


Fig. 4-2. No. 170 solid plastic gage shown on stand provided for all Dwyer portable inclined gages. Magnetic clips are also furnished to permit easy mounting on any vertical steel surface.

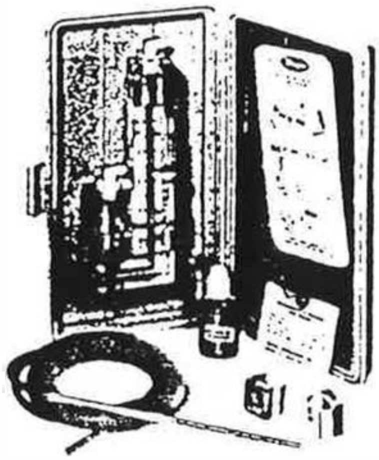


Fig. 4-3. No. 104 solid plastic portable vertical manometer shown attached to inside of carrying case cover. Gage may also be removed from case and used in standing position or attached to any vertical steel surface with magnetic clip provided.

SPECIAL PURPOSE PORTABLE GAGE KITS

NO. 400 AIR VELOCITY METER KIT

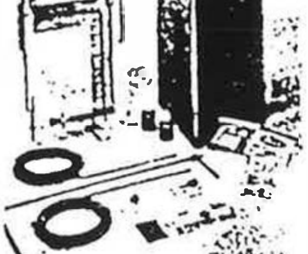


Fig. 4-4.

Dual scale inclined-vertical manometer reads in feet per minute from 500 FPM and inches of water with 0.01" W.C. minor divisions. Furnished as a complete kit. See Bulletin No. H-100.

NO. 102-AV and NO. 115-AV AIR VELOCITY KITS

Fig. 4-5.

Complete kits include solid plastic gages No. 102 or No. 115 described above with dual scales in feet per minute and inches of water and all accessories necessary for measurement of air velocity. See Bulletin H-100 for further information.

SERIES VT-170 AIR VOLUME GAGE KITS

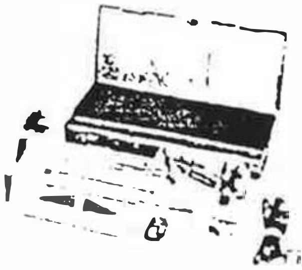


Fig. 4-6

Complete kits for use in determining air volume by reading differential pressure across air conditioning coils use gages No. VT-170, No. VT-171 and No. VT-172 described above. See Bulletin No. H-100.

RANGES AND DIMENSIONS

Suitable for total pressures up to 100 psig, temperatures up to 150° F
Accuracy ± 2% of full scale (1% on model 115 only)

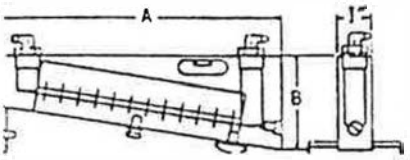


Fig. 5-1.

INCLINED TYPE

Model No.	Range Inches of Water	Minor Scale Divisions	Scale Length	Dimensions A	Dimensions B	Carrying Case Type	Carrying Case Dimensions	Weight lbs-oz.
100	.10-0-1.0	.02	5½"	8 13/16	3⅛	Plastic	12¼ x 6¼ x 1¾	3- 7
100.5	.10-0-1.0	.01	8¼"	11 11/16	2 13/16	Plastic	13½ x 10 x 2⅜	5- 1
101	.05-0- .50	.01	5"	8½	2 3/16	Plastic	12¼ x 6¼ x 1¾	3- 5
102	.20-0-2.0	.02	8¼"	11½	4 3/16	Plastic	13½ x 10 x 2⅜	5- 9
102.5	.20-0-2.0	.01	8¾"	12	4½	Plastic	13½ x 10 x 2⅜	5-10
108	.50-0- .50	.02	5"	8 13/16	3⅛	Plastic	12¼ x 6¼ x 1¾	3- 7
109	.20-0-3.0	.02	8¾"	11½	5 11/16	Plastic	13½ x 10 x 2⅜	6
115	.05-0- .25	.005	6"	9½	3 1/16	Plastic	12¼ x 6¼ x 1¾	3-10
170	0-.50	.02	2½"	5¾	2 7/16	Plastic	7 x 9	1- 7
171	0-.25	.01	2½"	5¾	1⅞	Plastic	7 x 9	1- 6
172	0-1.0	.02	3¼"	6⅜	2⅞	Plastic	7 x 9	1- 9

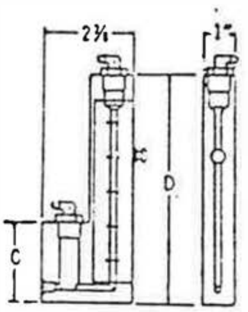


Fig. 5-2.

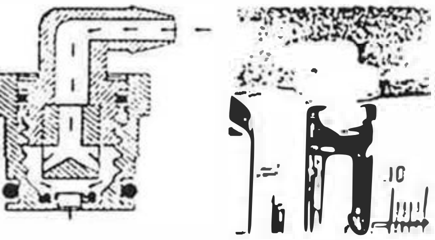
VERTICAL TYPE

Model No.	Range Inches of Water	Minor Scale Divisions	Scale Length	Dimensions C	Dimensions D	Carrying Case Type	Carrying Case Dimensions	Weight lbs-oz.
104	0- 4	.10	4½"	3 11/16	8¼	Plastic	12¼ x 6¼ x 1¾	3- 0
104-6	0- 6	.10	7¾"	4 3/16	10⅞	Plastic	13½ x 10 x 2⅜	4- 8
104-8	0- 8	.10	9"	4⅝	13 3/16	Metal	18½ x 4⅜ x 2¼	4-12
104-10	0-10	.10	11⅛"	5 3/16	15¼	Metal	18½ x 4⅜ x 2¼	4-15

STANDARD ACCESSORIES: plastic or steel carrying case, (except 170, 171, and 172 which include plastic pouch) pair of magnetic mounting clips, two molded nylon tubing connectors, rapid shutoff type, one 9' length rubber tubing and one brass terminal tube, extra bottle of .826 sp. gr. red gage oil.

TANDARD EQUIPMENT FOR SOLID PLASTIC PORTABLE MANOMETERS

MOLDED NYLON RAPID SHUT OFF TUBING CONNECTORS



g 5 3. Exclusive Dwyer leak-proof, corro-on-proof, virtually unbreakable molded ylon connector requires just one counter-lockwise turn to open, one clockwise turn close. Rotating connector seats on O ng for absolute closure and is O-ring ealed at top Connector body is also O ng sealed and is easily removed for eaning or adding fluid

MAGNECLIPS FOR SPLIT SECOND MOUNTING ON ANY STEEL SURFACE

Fig. 5 4. Dwyer mounting magnets are attached to all Dwyer solid plastic inclined portable gages (left, above) and furnished as clips that can be attached to all Dwyer solid plastic vertical portable gages (right, above). Just touch the magnets to any vertical steel surface; gage will "stay put" until it is forcibly detached.

HIGH DENSITY POLYETHYLENE FOAM LINED CARRYING CASES

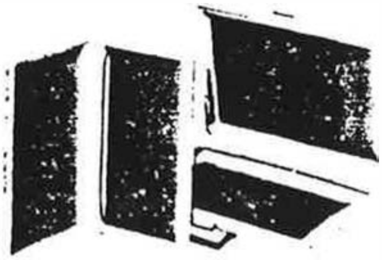


Fig 5 5 Most Dwyer portable gages are furnished with carrying cases of high density polyethylene Models 104-8 & 104-10 have steel cases. For protection of the gage and accessories, both plastic and steel cases are lined with resilient polyurethane plastic foam Nos 170, 171 & 172 include plastic pouch

APPENDIX 4:

DETAILED RESULTS FOR TEST SERIES 1 - BACKDRAFT TESTING

TABLE 1 EFFECT OF DEPRESSURIZATION ON CHIMNEY FLOW

Conventional burner fan adjusted for 1.25 USGPH nozzle, no oil flow.

	Test 11:30 to 12:30	Test 13:30
Pressure (Pa)	Time to Reverse Flow Seconds	Time to Stop Spillage Seconds
0	no backdraft	no spillage
4	no backdraft	no spillage
6	0	no spillage
8	1/4	7
10	1/4	spillage
12	1/2	spillage
14	1/2	spillage
16	1/2	spillage
18	1/2	spillage
20	3/4	spillage
22	1/2	spillage
24	1/2	spillage
26	1/2	spillage
30	1/2	spillage
35	1/2	spillage
40	3/4	spillage
45	1/2	spillage
50	1/2	spillage
55	1/2	spillage
60	1/2	spillage

limit of manometer

Date of Test: January 28, 1987

Interior Temperature: 21°C

Time	12:00	13:00	14:00
Exterior Temperature °C	-11	-10	-10
Wind Speed* kph	15	19	19

*at weather station. No wind observed on site.

EFFECT OF HOUSE DEPRESSURIZATION ON FLOW VELOCITY

Flow 1 meter above breech. No oil flow.

Depressurization (Pa)	Feet/Min	Burner Fan	
0	10 to 20	OFF	Natural Draft
0	80 to 100	ON	
5	70 to 90	ON	
10	40 to 50	ON	
15	38 to 42	ON	
20	25 to 28	ON	
25	18 to 20	ON	
30	10 to 12	ON	
35	10	ON	
40	5 to 7	ON	
45	3	ON	
50	1 to 2	ON	
55	0 to 2	ON	
60	0 to 2	ON	
65	0	ON	Flow Reversal
70	0 to -10	ON	
75	-5 to -12	ON	
80	-15 to -30	ON	
85	-30 to -50	ON	

TEST SERIES 2 - STATIC PRESSURE TESTS

Objective

This series of tests was designed to repeat Moffat's pressure measurements on the oil burner fan. It was believed that the static pressure achieved by the burner fan would indicate the degree to which this option would address venting failure.

In this series of tests the flue was blocked and the pressure induced by the burner fan and induced air fan was measured over time with a manometer and stopwatch at Point B (downstream from both fans). These tests were conducted to determine:

(a) the time required to reach maximum fan effectiveness in order to determine the optimum length of delay for the solenoid valve; and

(b) the maximum pressure each fan was capable of producing as a comparison of relative power of the fans and ability to overcome negative pressure.

Summary of Results

The maximum static pressure achieved by the conventional burner of 19.5 Pa is well below that measured by Moffat in his tests achieving 30 Pa. Higher results were established by the high pressure burner.

1A: All burner fans obtain 2/3 maximum pressure within the first 10 sections of operation.

1B: The maximum pressure developed is highly dependent on supply air as determined by nozzle size and the associated adjustment of the air supply damper.

1C: The pressure of the draft inducing fan is dependent on the burner (despite the presence of an operating barometric damper). This may mean that the draft inducing fan could affect burner performance.

1D: When both burner fan and draft inducer fan are working together, differences due to burners disappear. This would be the typical mode of operation if a draft assisting fan was installed. A draft assisting fan with a burner reaches 2/3 of maximum pressure within 10 seconds. This indicates that a recommendation to utilize the induced draft fan would be accompanied by a recommendation to use it with a burn delay such as offered by a delayed action solenoid valve.

Test Results

Note: The burners are never firing in these tests. Only the fans of the burners are used. Pressure is measured at Point B.

TEST 2A - Burner Fan Only

Conventional Burner		High Pressure Burner 0·95 Nozzle		High Pressure Burner 0·60 Nozzle	
Induced Pressure (Pa)	Time (sec)	Pressure (Pa)	Time (sec)	Pressure (Pa)	Time (sec)
1	1.0	1	2.2	1	3.7
2	1.7	2	3.5	2	6.3
3	2.4	3	3.8	3	11.4
4	2.9	4	4.4		
5	3.9	5	5.6	3.9 max	30.2
6	5.1	6	6.1		
7	6.2	7	6.8		
8	9.1	8	7.5		
9	11.8	9	8.3		
9.5 max	15.6	10	10.0		
		11	11.9		
		12	12.7		
		13	16.0		
		14	19.0		
		15	26.6		
		15.5 max			

In this test the high pressure burner was tested with two different nozzles. Note that the bigger nozzle and the associated bigger air supply increases the pressure drastically.

TEST 2B - Draft Inducer Only

Note: The high efficiency burner has an automatic air damper which is closed when the burner fan is not operating. The barometric damper was operating in both cases.

Induced Pressure (Pa)	Conventional Burner Not Working Time (sec)	High Pressure Burner Not Working Time (sec)	
1	3.7	3.4	3.5
2	4.2	4.1	4.3
3	4.9	4.9	4.9
4	5.4	5.4	5.1
5	6.2	5.7	5.7
6	6.7	6.4	6.4
7	7.5	6.6	6.7
8	7.9	7.1	7.4
9	8.2	7.9	7.9
10	8.9	8.1	8.2
11	9.9	8.5	8.7
12	11.2	10.3	8.9
13	13.8	9.6	10.0
14	15.1	11.1	11.4
15	16.1	10.6	11.9
16	22.2*	12.4	13.6
17		12.9	13.2
18		14.5	14.7
19		15.3	16.2
20		16.7	18.5
21		17.6	18.8
22		19.3	25.9
23		26.9*	

Steady state: conventional burner = 16±0.5 Pa (fluctuating)

Steady state: Riello burner = 24 ±0.5 Pa (fluctuating)

*measurement is the average of 3 readings

Note: The significant difference, given that the same fan is tested in both cases, was noted. The repeat test with the high pressure burner was run to verify previous test results. It is conjectured that the difference in pressure is due to varying air turbulence at the barometric damper.

TEST 2C - Both Fans Operating Simultaneously

Induced Pressure (Pa)	Draft Inducer and Conventional Burner Time (sec)	Draft Inducer and Conventional Burner Time (sec)
1		2.56
2		3.31
3	2.60	3.85
4		4.35
5	3.32	4.73
6		5.15
7	4.03	5.54
8		5.83
9		6.00
10	4.60	6.39
11		6.88
12	5.57	6.89
13		
14		7.81
15	6.21	
16		8.55
17	6.85	
18		9.18
19		
20	7.80	9.60
21		
22	8.56	10.75
23		
24		11.87
25	10.48	
26	9.98	12.94
27	11.03	
28	12.45	14.15
29	14.13	
30	16.34	16.88
31	21.21	
32	22.68	19.41

TEST SERIES 3 - SPILLAGE TESTING

TEST 3A-1 - Cold Chimney, Oil Burners Not Firing

Pressure at Which Spillage was Observed (Pa)

Observation Point	Conventional Burner Cross-over	Conventional Burner Spillage	High Efficiency Burner Cross-over	High Efficiency Burner Spillage
Condition 1: No fans on				
Point A	5	6	6	8
B	5	6	4	6
C	5	5	7	9
Condition 2: Burner fan only				
Point A	1	4	1	2
B	1	2	1	2
C	1	2	3	7
Condition 3: Induced draft fan only				
Point A	30	35	23	28
B	11	15	5	8
C	29	33	30	35
Condition 4: Both fans on				
Point A	18	24	18	23
B	5	13	1	7
C	18	26	23	31

NOTE: In some cases, particularly Condition #2 on the conventional burner, it was difficult to differentiate between cross-over and spillage, i.e., spillage occurred almost immediately.

Date of Test: March 24, 1986
Interior Temperature: 21.0°C

Time	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Exterior Temperature: °C	-2.5	-1.1	0	1.5	2.6	3.4	3.2	2.9	1.3
Wind Speed: kph	15	19	19	19	15	19	19	22	15

TEST 3A-2 - Cold Chimney, Oil Burners Not Firing

Pressure at Which Spillage was Observed (Pa)

Observation Point	Conventional Burner		High Efficiency Burner	
	Cross-over	Spillage	Cross-over	Spillage
Condition 1: No fans on				
Point A	1	2	5	7
B	0	1	2	3
C	1	2	5	6
Condition 2: Burner fan only				
Point A	0	1	3	4
B	1	1	1	2
C	0	1	1	1
Condition 3: Induced draft fan only				
Point A	25	30	24	31
B	5	10	1	15
C	19	30	28	32
Condition 4: Both fans on				
Point A	16	18	18	23
B	4	11	1	14
C	12	16	24	28

NOTE: In some cases, particularly Condition #2 on the conventional burner, it was difficult to differentiate between cross-over and spillage, i.e., spillage occurred almost immediately.

Date of Test: April 1. 1986

Interior Temperature: 21.0°C

Time	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Exterior Temperature: °C	6.2	6.8	7.5	7.6	9.0	9.1	9.5	9.2	10.0
Wind Speed: kph	13	C	13	13	15	15	15	15	22

TEST 3B-1 - Hot Chimney*

Pressure at Which Spillage was Observed (Pa)

Observation Point	Conventional Burner		Riello Burner	
	Cross-over	Spillage	Cross-over	Spillage
<u>Condition 1</u>: Burner off, draft inducer off				
Point A	1	4	4	6
B	1	5	3	6
C	3	5	8	10
<u>Condition 2</u>: Burner firing, draft inducer off				
Point A	10	14	7	10
B	7	9	1	7
C	12	17	12	20
<u>Condition 3</u>: Burner off, draft inducer on				
Point A	12	20	22	30
B	4	10	0	14
C	27	33	31	38
<u>Condition 4</u>: Burner firing, draft inducer on				
Point A	15	21	15	23
B	21	27	2	15
C	21	33	21	32

*The burner was operated with oil for fifteen minutes to warm the chimney prior to testing.

Date of Test: March 25, 1986

Interior Temperature: 21.0°C

Time	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Exterior Temperature: °C	-8.8	-8.2	-7.7	-6.8	-6.6	-5.6	-5.0	-4.0	-3.4
Wind Speed: kph	28	28	28	28	24	19	15	9	7

TEST 3B-2 - Hot Chimney*

Pressure at Which Spillage was Observed (Pa)

Observation Point	Conventional Burner		Riello Burner	
	Cross-over	Spillage	Cross-over	Spillage
Condition 1: Burner off, draft inducer off				
Point A			5	6
B			1	5
C			3	5
Condition 2: Burner firing, draft inducer off				
Point A	3	5	4	8
B	0	3	0	3
C	3	9	3	9
Condition 3: Burner off, draft inducer on				
Point A	18	29	18	29
B			4	10
C			27	35
Condition 4: Burner firing, draft inducer on				
Point A	5	18	12	20
B	2	10	2	10
C	11	19	11	19

*The burner was operated with oil for fifteen minutes to warm the chimney prior to testing.

Date of Test: April 2, 1986

Interior Temperature: 21.0°C

Time	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Exterior Temperature: °C	8.4	10.2	11.7	13.0	14.1	13.8	14.0	11.6	9.0
Wind Speed: kph	24	22	24	19	19	28	13	22	19

APPENDIX 5:

TEST SERIES 4 - DETAILED TEST RESULTS OF THE DAMPERLESS, INSULATED FLUE WITH HIGH PRESSURE BURNER

Test Weather Data applies to all Series 4 tests.

Date	Interior Temperature °C	Exterior Temperature °C	Wind Speed k/hr
Losier before March 20	18	1.9	24.7
Losier after April 1	18	7.3	8.7
Piercy before March 23	18	-0.9	18.3
Piercy after April 11	18	7.6	11.7

Temperatures are daily highs recorded at the Charlottetown Weather Station. Winds are daily averages. For further weather details see Appendix 6.

Negative Pressures Created by Appliances

	Losier (Pa)	Piercy (Pa)
air exchanger (inlet blocked)	6.5	2.3
dryer	1.5	3.0
both	7.5	5.6

Environment Canada / Environnement Canada
Atmospheric Environment Service / Service de l'environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS MARCH/MARS 1986

AT/À CHARLOTTETOWN (A), PRINCE EDWARD ISLAND/ILE DU PRINCE EDOUARD

LAT: 46° 17' N LONG. 63 08 W ELEVATION/ALTITUDE: 54.5 METRES (ASL)/METRES (NMM) STANDARD TIME USED/HEURE NORMALE UTILISÉE: ATLANTIC/ATLANTIQUE

DATE	TEMPERATURE Maximum/Maximale °C	TEMPERATURE Minimum/Minimale °C	TEMPERATURE Mean/Moyenne °C	DEGREE-DAYS Heating/De chauffe base 18°C	DEGREE-DAYS Growing/De croissance base 5°C	REL. HUMIDITY Maximum/Maximale %	REL. HUMIDITY Minimum/Minimale %	Thunderstorm/Orage	PRECIPITATION Rainfall/Pluie (hauteur) mm	PRECIPITATION Snowfall/Neige (hauteur) cm	PRECIPITATION Total precip./Précip. totale mm	Snow on ground/Neige au sol cm	WIND Average speed/Vitesse moyenne km/h	WIND Prevailing direction/Direction dominante	WIND Maximum speed and direction/Vitesse maximale et direction km/h	Bright sunshine/Insolation effective Hours/Heures
1	1.3	-6.5	-2.6	20.6								27	16.0	SSW	22 SSW*	4.4
2	-3.0	-8.8	-5.9	23.9								25	15.2	N	22 NNE*	0.0
3	0.8	-10.2	-4.7	22.7								23	13.9	W	22 W	8.4
4	2.0	-10.8	-4.4	22.4								21	8.8	S	15 WSW	8.7
5	3.2	-6.1	-1.5	19.5								20	9.7	S	15 SSE	5.3
6	-2.0	-13.3	-7.7	25.7						0.6	0.4	18	18.3	N	29 N*	4.2
7	-6.5	-12.6	-9.6	27.6						13.4	13.2	21	22.1	NE	33 NE*	2.7
8	-6.3	-13.8	-10.1	28.1						TR	TR	30	23.9	WNW	37 WNW*	3.4
9	-7.8	-15.7	-11.8	29.8								29	16.3	WSW	24 WSW	10.1
10	-13.6	-19.8	-16.7	34.7						7.2	7.8	28	16.0	N	33 N	6.4
11	2.4	-12.2	-4.9	22.9					1.2	9.6	12.3	39	24.0	SE	33 NW*	0.0
12	-7.1	-17.6	-12.4	30.4						TR	TR	36	21.8	NW	37 NW*	8.5
13	-2.2	-16.2	-9.2	27.2								35	10.5	SW	15 SSW*	6.0
14	0.2	-4.1	-1.9	19.9						TR	TR	34	9.9	E	19 ENE	0.0
15	-0.2	-6.3	-3.3	21.3					8.5	17.8	29.7	38	21.0	E	25 NNE*	0.0
16	-1.5	-10.8	-6.2	24.2						1.0	0.6	44	6.6	Svrl	28 NNW	0.8
17	-2.5	-9.8	-6.2	24.2						TR	TR	43	5.1	NW	15 NW	0.1
18	2.4	-12.2	-4.9	22.9								42	12.0	SW	24 SSW	7.9
19	6.2	-3.2	1.5	16.5					11.0		11.0	39	24.9	S	37 S*	1.0
20	5.8	-13.8	-4.0	22.0								31	22.2	W	30 W*	8.5
21	-7.6	-17.4	-12.5	30.5								25	18.9	W	28 W*	10.5
22	-1.9	-12.0	- 7.0	25.0								22	11.5	WSW	19 WSW*	10.3
23	3.4	-9.3	-3.0	21.0								21	16.7	S	26 S	10.2
24	4.0	-7.5	-1.8	19.8					0.2	TR	0.2	20	20.1	S	37 NW*	3.5
25	-2.8	-10.4	--6.6	24.6						0.2	0.2	19	19.4	WNW	28 WNW*	10.8
26	10.6	-4.0	3.3	14.7						TR	TR	19	22.1	S	33 S	6.8
27	8.8	-3.0	2.9	15.1					7.7	1.2	10.8	8	20.1	NE	26 SW*	2.0
28	-2.0	-8.8	-5.4	23.4					8.4	11.8	22.0	6	24.3	NE	28 NE*	0.0
29	5.2	-8.8	-1.8	19.8					2.4		2.4	17	18.5	S	28 S	0.0
30	12.2	1.5	6.9	11.1	1.9				TR		TR	10	14.4	S	24 SSE*	7.8
31	11.6	3.8	7.7	10.3	2.7							6	20 5	S	28 W*	6.6
MEAN/MOYENNE	0.5	-9.7	-4.6	TOTAL 701.8	TOTAL 4.6			TOTAL	TOTAL 39.4	TOTAL 64.0	TOTAL 110.6		16.9	PREVAILING S DOMINANTE	MAXIMUM 37 WNW*	TOTAL 154.9
NORMAL/NORMALE	0.6	-6.8	-3.1	653.9	1.1				31.8	61.6	95.3		21.9	W		134.9

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C / AU-DESSOUS DE 18°C	This year / Année en cours	Previous year / Année précédente	Normal / Normale	ABOVE 5°C / AU-DESSUS DE 5°C	This year / Année en cours	Previous year / Année précédente	Normal / Normale
TOTAL FOR MONTH / TOTAL DU MOIS	701.8	702.1	653.9	TOTAL FOR MONTH / TOTAL DU MOIS	4.6	0.0	1.1
ACCUMULATED SINCE JULY 1 / ACCUMULÉE DEPUIS LE 1er JUILLET	3918.0	3918.3	3604.0	ACCUMULATED SINCE APRIL 1 / ACCUMULÉE DEPUIS LE 1er AVRIL	1733.3	1728.7	1625.9

	DAYS WITH TOTAL PRECIPITATION / JOURS AVEC PRÉCIPITATIONS TOTALES (mm)					DAYS WITH SNOWFALL / JOURS AVEC CHUTE DE NEIGE (cm)				
	0.2 or more / ou plus	1.0 or more / ou plus	2.0 or more / ou plus	10.0 or more / ou plus	50.0 or more / ou plus	0.2 or more / ou plus	1.0 or more / ou plus	2.0 or more / ou plus	10.0 or more / ou plus	50.0 or more / ou plus
	12	8	8	6	0	9	7	5	3	0

UDC 551.506.1 (

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Prix d'abonnement: mensuel $1.06; annuel $10.60 (janvier à décembre)

*DENOTES LATER OCCURRENCE AT SAME SPEED BUT NOT NECESSARILY FROM THE SAME DIRECTION.

Canada

CHARLOTTETOWN (A) P.E.I.

COMPARATIVE RECORDS
RELEVES COMPARATIFS

MONTH MARCH
MOIS MARS

19 86

Temperature/Température – °Celsius
Precipitation/Précipitation – Millimetres (mm)
Rainfall/Hauteur de pluie – Millimetres (mm)
Snowfall/Hauteur de neige – Centimetres (cm)
Wind speed/Vitesse du vent – Kilometres per hour/par heure (km/h)
Station pressure/Pression à la station – Kilopascals (kPa)

	THIS MONTH CE MOIS-CI		PREVIOUS YEAR ANNEE PRECEDENTE		NORMAL NORMALE	RECORD FOR THE MONTH RECORD POUR LE MOIS						Years of record Années d'observations
						HIGHEST MAXIMUM ABSOLU			LOWEST MINIMUM ABSOLU			
	VALUE RELEVE	DATE	VALUE RELEVE	DATE		VALUE RELEVE	DAY JOUR	YEAR ANNEE	VALUE RELEVE	DAY JOUR	YEAR ANNEE	
HIGHEST TEMPERATURE TEMPERATURE LA PLUS ELEVEE	12.2	30	5.1	29		16.1	29	1943	4.4	31	1953	43
LOWEST TEMPERATURE TEMPERATURE LA PLUS BASSE	-19.8	10	-19.5	06		-19.5	06	1985	-23.9	13	1948	43
MEAN MONTHLY TEMPERATURE TEMPERATURE MENSUELLE MOYENNE	-3.1		-4.7		-3.2	-0.2		1946	-7.2		1967	43
TOTAL MONTHLY RAINFALL HAUTEUR TOTALE MENSUELLE DE PLUIE	39.4		27.1		31.8	74.9		1945	1.8		1946	43
TOTAL MONTHLY SNOWFALL HAUTEUR TOTALE MENSUELLE DE NEIGE	61.6		40.0		61.6	166.9		1967	2.8		1946	43
TOTAL MONTHLY PRECIPITATION PRECIPITATION TOTALE MENSUELLE	110.6		62.8		95.3	196.1		1972	4.6		1946	43
NO OF DAYS WITH MEASURABLE PRECIPITATION NOMBRE DE JOURS AVEC PRECIPITATION MESURABLE	12		12		15	20		1949	7		1946	43
GREATEST RAINFALL IN ONE DAY HAUTEUR DE PLUIE MAXIMALE EN UNE JOURNEE	11.0	19	13.4	12		35.1	23	1945				43
GREATEST SNOWFALL IN ONE DAY HAUTEUR DE NEIGE MAXIMALE EN UNE JOURNEE	17.8	15	15.9	5		33.8	14	1945				43
GREATEST PRECIPITATION IN ONE DAY PRECIPITATION MAXIMALE EN UNE JOURNEE	29.7	15	13.6	5		44.2	12	1968				43
MAXIMUM RAINFALL RECORDED IN HAUTEUR DE PLUIE MAXIMALE ENREGISTREE EN:												
5 MINUTES												
10 MINUTES												
15 MINUTES												
30 MINUTES												
60 MINUTES												
24 CONSECUTIVE HOURS HEURES CONSECUTIVES												
MEAN WIND SPEED km/h VITESSE MOYENNE DU VENT km/h	16.9		18.8		21.9	27.4		1964	16.9		1986	31
MAXIMUM SPEED (1 min) km/h VITESSE MAXIMALE (1 min) km/h	37 WNW	08	41 WNW	30		97 ESE		1966	37 WNW		1986	31
MAXIMUM GUST SPEED km/h POINTE DU VENT MAXIMALE km/h	65 NW	24	74 W	03		132 WSW		1969	61 SW		1971	31
TOTAL HOURS OF SUNSHINE TOTAL DES HEURES INSOLATION	155		148		137	204		1973	64		1952	71
MEAN STATION PRESSURE kPa PRESSION MOYENNE A LA STATION kPa	100.74		100.37		100.37	101.12		1967	99.63		1981	24
GREATEST STATION PRESSURE kPa PRESSION MAXIMALE A LA STATION kPa	103.02	25	103.71	07		103.89	13	1984				10
LEAST STATION PRESSURE kPa PRESSION MINIMALE A LA STATION kPa	96.81	07	98.42	15					95.41	17	1981	10

CLIMATOLOGICAL DATA FOR THE PAST 10 YEARS
DONNEES CLIMATOLOGIQUES POUR LES 10 DERNIÈRE ANNÉES

YEAR ANNEE	MAXIMUM TEMP TEMP MAXIMALE	MINIMUM TEMP TEMP MINIMALE	MEAN TEMP TEMP MOYENNE	RAINFALL HAUTEUR DE PLUIE	SNOWFALL HAUTEUR DE NEIGE	TOTAL PRECIP PRECIP TOTALE	MEAN WINDSPEED VITESSE MOYENNE DES VENTS	MAXIMUM WINDSPEED VITESSE MAXIMALE DES VENTS	HOURS SUNSHINE HEURES INSOLATION	HEATING DEGREE DAYS DEGRES-JOURS DE CHAUFFE	GROWING DEGREE DAYS DEGRES-JOURS DE CROISSANCE		
1976	13.9	-16.1	-2.9	12.4	42.5	61.0	20.8	56 ESE	164			12	
1977	9.7	-9.6	-0.9	28.0	79.6	107.3	21.9	65 N	126	586.6		12	
1978	6.9	-15.7	-4.6	12.2	45.8	55.0	21.2	56 W	137	707.6		18	
1979	15.1	-17.2	-0.6	72.5	28.0	105.8	22.0	57 NNE	117	573.3		16	
1980	5.9	-19.8	-4.1	26.4	38.6	66.7	23.4	56 NNE	110	683.6		15	
1981	8.3	-9.4	-0.5	38.8	31.6	69.6	19.1	67 NE	94	572.7	0.3	13	
1982	9.0	-20.5	-4.2	33.0	22.4	54.5	18.4	46 NNW	156	683.6	0.6	12	
1983	12.7	-12.0	-1.0	54.9	24.3	79.9	22.0	65 NW	88	589.6	6.7	17	
1984	13.8	-19.0	-3.8	75.9	56.9	129.2	27.3	56 NE	126	677.8	4.0	17	
1985	5.1	-19.5	-4.7	27.1	40.0	62.8	18.8	41 WNW	148	702.1	0.0	12	
1986	12.2	-19.8	-3.1	39.4	61.6	110.6	16.9	37 WNW	155	701.8	4.6	12	

CHARLOTTETOWN (A) P.E.I.

WIND SUMMARY (Kilometres per hour)
SOMMAIRE DES VENTS (Kilomètres par heure)

MONTH MARCH
MOIS MARCH

1986

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Peak Gust Rafale maximum	Hour Heure
1	S 19	S 19	SSW 22	S 19	SSW 19	S 15	S 13	SSW 15	S 19	SSW 13	SSW 19	SSW 19	SSW 19	WSW 15	WSW 22	WSW 19	SW 19	SW 11	SSW 9	SSW 19	SSW 15	WSW 9	W 11	W 19	N 33	1700
2	WNW 6	NW 9	NW 9	NNW 9	N 9	N 9	NE 9	NE 9	NNE 9	NE 11	NE 19	NNE 19	NE 22	N 22	N 22	N 22	N 22	N 22	NNW 19	NNW 19	NNW 17	NW 19	W 13	WNW 19		
3	W 9	W 15	WSW 15	WSW 15	W 15	WSW 15	W 19	WSW 15	WSW 15	W 19	W 13	WSW 13	WSW 15	WSW 15	W 19	W 19	W 22	SW 6	SSW 6	SSW 9	SW 11	SSW 11	SW 9	WSW 13		
4	WSW 9	SW 13	SW 11	WSW 15	WSW 13	WSW 9	WSW 9	S 7	S 9	SSW 7	S 7	S 11	SSW 9	SSW 9	S 7	S 7	SE 9	SE 9	SW 6	SSW 7	SW 6	S 7	SSW 7	SSE 9		
5	S 7	S 9	S 9	S 9	S 9	S 9	S 9	S 9	S 9	S 11	S 11	SSE 7	SSE 11	S 9	SSE 13	SE 13	SE 15	SE 13	SSE 11	SE 7	SE 7	S 7	SSW 9	WSW 9		
6	WSW 9	WNW 15	NW 22	N 28	NNW 22	N 25	N 26	N 25	N 28	N 22	N 22	N 25	NW 22	NNW 19	NW 17	N 15	NW 15	N 9	ENE 11	E 6	E 9	ESE 9	ESE 11	E 9	N 37	0300
7	ESE 15	ESE 11	E 19	E 19	E 19	ENE 20	E 22	NE 28	NE 33	NE 33	NE 33	ENE 28	NE 22	N 9	SSW 11	SW 26	WSW 25	WSW 28	W 22	W 22	W 22	W 19	WSW 19	WSW 15		
8	SW 9	SSW 9	WSW 13	WSW 28	W 22	W 22	W 19	W 28	W 28	W 26	WNW 30	WNW 33	WNW 37	WNW 37	WNW 33	W 26	N 26	WNW 22	WNW 22	WNW 22	WNW 19	WNW 19	WNW 22	WNW 22	NE 56	0900
9	WNW 22	W 19	WNW 22	WNW 19	W 19	WSW 13	WSW 15	W 22	W 7	W 22	W 22	WSW 15	SW 19	WSW 19	WSW 19	WSW 19	WSW 24	WSW 13	W 9	WSW 9	W 9	W 15	WNW 9	WSW 9	WNW 65	1300
10	NW 24	N 33	N 26	N 28	N 26	N 22	N 19	NNE 11	NNE 11	N 19	N 19	N 11	N 15	NNE 9	N 7	E 7	C	SSW 9	SSW 9	ESE 9	E 13	ESE 19	ESE 19	ESE 19	N 56	0100
11	ESE 15	SE 22	SE 22	ESE 22	ESE 22	ESE 22	SE 22	SE 22	SE 22	SE 28	SE 25	SE 26	SSE 25	SSW 21	SSW 28	SSW 22	WSW 19	W 22	NW 19	NNW 19	NW 28	NW 33	NW 33	NW 33	NW 56	2300
12	NW 37	NW 37	NW 30	NW 22	WNW 22	WNW 22	WNW 19	WNW 19	WNW 22	NW 22	NW 28	WNW 28	NW 26	WNW 28	NW 29	NW 25	NW 25	NNW 22	NW 19	NNW 9	C	W 6	W 9	WNW 9	NNW 59	0000
13	C	C	C	C	SW 7	SSW 11	SW 15	SW 11	SW 11	SW 9	SSW 9	SSW 13	SSW 15	SSW 15	SW 9	SSW 15	SSW 13	SSW 15	SSW 11	WSW 19	SW 11	WSW 15	WSW 13	WSW 15		
14	NNE 9	NNE 9	SSE 9	C	C	C	NE 9	E 9	ENE 9	ENE 9	S 11	E 11	ENE 13	E 13	E 15	ENE 19	E 11	ESE 13	ESE 11	ESE 11	ENE 9	E 11	ESE 13	ESE 13		
15	ESE 13	ESE 13	E 9	E 19	E 19	E 19	E 19	E 19	E 24	E 22	ENE 19	E 19	NE 28	E 19	ENE 19	NE 26	NE 22	NNE 28	NE 25	NE 37	NE 19	N 28	N 25	N 28		
16	NE 28	N 25	NNW 22	N 19	NW 19	NW 9	W 9	C	C	C	C	SE 9	C	C	C	C	NE 6	C	E 7	SE 7	C	C	C	C		
17	C	C	C	C	C	C	C	C	C	NNW 7	NW 9	NW 15	NW 15	NNW 11	NW 11	N 15	N 15	N 9	C	C	C	9	SW 7	SSW 9		
18	SSW 7	SW 7	SW 9	SW 7	S 9	SSW 9	S 7	S 7	S 7	SSW 9	SSW 9	SW 15	SSW 13	SSW 21	SSW 15	SW 15	SW 22	SW 19	SW 17	SW 11	SW 15	WSW 19	SW 15	SW 15		
19	SW 11	SW 13	SW 13	SW 15	S 11	S 9	S 22	S 28	S 19	S 22	S 26	S 26	S 25	S 26	S 30	S 33	S 33	S 33	S 37	S 37	SW 28	SSW 25	S 33	S 33	S 61	1600
20	SSW 22	SSW 22	SW 19	SSW 19	SSW 19	SW 19	SW 19	W 19	WSW 19	WSW 19	W 22	W 28	W 22	W 30	W 22	W 22	WNW 25	WNW 26	WNW 28	WNW 19	WNW 15	WNW 22	WNW 22	W 28	W 52	1300
21	WNW 21	WNW 26	W 22	W 26	W 22	W 22	W 22	W 22	W 22	W 28	WNW 25	W 28	W 22	W 19	W 19	W 13	WSW 15	W 9	WSW 9	S 11	S 11	S 11	SSW 11	SSW 9	W 48	0300
22	SW 7	SW 9	SW 9	SSW 7	SSW 7	SSW 7	SSW 7	SW 11	WSW 15	WSW 19	WSW 22	WSW 19	WSW 13	WSW 13	WSW 15	SW 13	WSW 15	WSW 19	SSW 11	SSW 7	SW 7	SW 9	SW 9	SW 11		
23	SW 9	SSW 9	S 9	S 9	SSE 9	S 9	S 9	SSE 9	S 9	S 17	S 19	S 19	S 19	S 22	S 22	S 24	S 26	S 25	S 22	S 15	SSE 22	SSE 22	S 22	S 22	S 37	1300
24	SSE 22	S 19	S 19	S 13	S 13	S 9	S 13	S 9	S 9	SSW 15	SSW 19	SW 19	SW 19	SSW 15	SSW 19	WSW 19	WSW 22	W 19	NW 22	NW 37	NW 33	NW 33	NW 37	WNW 33	NW 65	2200
25	WNW 28	WNW 28	WNW 28	WNW 26	WNW 22	WNW 22	WNW 22	W 22	W 22	WNW 28	W 25	W 25	W 25	NW 24	WNW 19	WNW 15	WNW 9	WSW 7	S 7	SSW 11	SE 9	SE 9	S 11	SE 15	WNW 41	0300
26	S 15	SSE 11	SE 15	SE 15	SE 15	SE 22	SE 19	SSE 28	S 25	S 33	S 22	S 26	S 19	SSW 22	SSW 26	SSW 19	SW 26	SW 28	SW 23	SW 25	SW 22	SSW 19	SW 19	SSW 26	SW 52	1600
27	SSW 22	SSW 22	SW 25	SW 22	SW 22	SW 22	SW 15	SW 19	WSW 15	WSW 22	WSW 22	W 19	NW 15	NNW 13	N 19	NE 15	NE 22	NE 13	NE 19	NNE 19	NE 22	NE 26	NE 26	NE 22	NE 41	2000
28	E 26	E 28	E 26	NE 19	NE 19	NE 28	NE 28	NNE 23	NE 19	NE 22	NNE 22	N 22	N 26	N 25	N 26	N 19	NNW 25	NNW 23	NW 28	NNW 28	NW 22	NW 26	NW 19	NNW 15		
29	WSW 11	WSW 7	W 7	C	SE 9	S 13	SSE 19	SE 19	SSE 22	S 26	S 22	S 22	S 25	S 25	S 25	S 26	S 23	SSW 22	SW 15	SW 22	WSW 19	WSW 13	SW 15	SSW 22	S 46	1300
30	S 19	S 15	SSW 7	SSW 15	SW 15	WSW 7	S 11	SW 11	S 7	S 6	S 9	S 9	SE 13	S 13	SE 9	SE 15	S 19	SE 19	S 15	S 22	SSE 24	S 22	SSE 24	S 19		
31	SE 15	S 22	S 22	S 26	S 22	S 26	S 22	S 19	S 22	S 22	SSW 19	SSW 22	WSW 19	W 13	W 19	NW 26	WNW 24	WNW 24	WNW 22	W 22	W 9	WNW 19	W 22	W 25	W 41	1300

On indique un vent d'ouest par la lettre 'W'.

*Indicates later occurrence of same speed
*Indique des données postérieures de la même vitesse

CHARLOTTETOWN (A.) P.E.I.

DRY-BULB TEMPERATURE SUMMARY*
SOMMAIRE DES TEMPÉRATURES DU THERMOMÈTRE SEC*

MONTH
MOIS

19

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-35	-34	-27	-24	-31	-39	-34	-24	-26	-27	-19	-02	00	06	09	12	12	02	-15	-25	-34	-26	-31	-41
2	-47	-65	-57	-72	-72	-79	-62	-62	-58	-49	-42	-39	-34	-41	-41	-44	-43	-42	-49	-56	-60	-70	-86	-76
3	-36	-21	-27	-64	-85	-29	-91	-99	-94	-73	-56	-42	-32	-21	-08	00	04	00	-28	-48	-44	-60	-48	-32
4	-34	-26	-59	-61	-73	-65	-68	-106	-88	-62	-44	-22	-08	08	11	15	17	12	-03	-21	-24	-42	-49	-44
5	-03	-49	-49	-56	-59	-60	-57	-54	-48	-27	-22	-08	03	18	24	26	25	19	14	06	-02	-14	-22	-28
6	-32	-24	-20	-24	-29	-47	-56	-63	-68	-74	-76	-78	-78	-81	-81	-84	-87	-89	-98	-103	-105	-117	-122	-133
7	-130	-125	-116	-106	-107	-106	-108	-116	-114	-101	-94	-94	-90	-61	-67	-66	-67	-72	-97	-112	-114	-116	-118	-122
8	-121	-114	-102	-107	-109	-109	-111	-111	-106	-96	-93	-89	-89	-85	-84	-73	-64	-80	-90	-99	-104	-112	-116	-122
9	-132	-137	-134	-141	-143	-152	-152	-155	-152	-136	-120	-112	-112	-102	-94	-80	-80	-82	-91	-100	-113	-121	-110	-137
10	-100	-120	-137	-155	-170	-180	-192	-196	-193	-178	-168	-162	-154	-142	-148	-142	-137	-147	-148	-149	-154	-154	-157	-156
11	-156	-150	-142	-134	-115	- 99	-84	-68	-48	-32	-20	08	26	34	44	42	36	06	-07	-20	-49	-64	-84	-93
12	-97	-94	-94	-102	-102	-108	-110	-112	-103	-92	-84	-80	-78	-79	-74	-76	-73	-77	-93	-107	-106	-108	-151	-168
13	-174	-174	-168	-164	-158	-154	-160	-156	-147	-142	-112	-91	-77	-60	-49	-34	-40	-43	-40	-24	-25	-23	-26	-22
14	-32	-27	-22	-36	-33	-40	-37	-36	-37	-32	-23	-11	-05	00	-06	-08	-11	-12	-15	-19	-21	-24	-25	-26
15	-21	-25	-27	-33	-35	-36	-38	-36	-34	-31	-25	-22	-13	-12	-04	-11	-12	-21	-33	-42	-44	-48	-56	-52
16	-54	-56	-63	-68	-83	-97	-106	-104	-100	-73	-59	-42	-36	-19	-17	-23	-25	-27	-26	-27	-32	-38	-40	-42
17	-42	-44	-46	-45	-47	-58	-57	-54	-46	-40	-26	-27	-30	-31	-29	-29	-29	-33	-32	-53	-64	-66	-66	-82
18	-95	-97	-94	-102	-117	-114	-119	-122	-114	-81	-50	-30	-09	10	16	18	22	22	18	12	07	08	00	-06
19	00	00	06	00	-22	-24	-28	-31	-23	-10	-08	13	19	24	26	30	30	38	36	40	46	46	53	50
20	44	51	53	53	49	53	46	40	32	46	47	40	33	21	19	18	13	06	-10	-22	-33	-50	-76	-74
21	-117	-130	-135	-147	-152	-156	-161	-162	-158	-148	-139	-132	-123	-116	-109	-100	-94	-87	-89	-95	-105	-108	-110	-114
22	-114	-116	-117	-114	-116	-117	-120	-115	-102	-84	-79	-68	-54	-42	-29	-24	-22	-23	-22	-33	-44	-56	-61	-65
23	-62	-68	-74	-74	-81	-86	-91	-80	-62	-48	-28	-10	02	22	28	32	32	22	14	-04	-13	-22	-32	-39
24	-42	-35	-39	-47	-54	-48	-54	-52	-41	-25	-11	00	15	25	34	32	29	13	-08	-14	-33	-46	-53	-66
25	-70	-73	-75	-84	-89	-93	-98	-102	-97	-88	-82	-77	-68	-66	-56	-50	-40	-34	-39	-49	-54	-55	-51	-44
26	-12	-32	-39	-37	-29	-23	-16	-09	02	13	26	42	57	86	97	104	100	93	90	90	89	90	83	83
27	67	72	80	67	75	56	60	73	65	82	75	66	25	05	00	00	00	-02	-06	-08	-10	-10	-12	-13
28	-23	-22	-25	-23	-26	-24	-25	-30	-30	-20	-20	-20	-20	-25	-29	-31	-35	-35	-33	-39	-36	-37	-38	-43
29	-79	-81	-87	-72	-76	-68	-48	-39	-25	-02	-05	-08	12	24	30	38	48	43	44	50	43	44	43	35
30	22	18	20	25	28	24	20	18	24	37	44	50	52	58	64	116	100	96	89	80	70	64	64	65
31	64	60	62	52	51	52	52	50	60	62	69	75	100	113	103	82	83	74	70	57	43	46	48	52

*Temperatures in tenths of degrees Celsius – Températures en dixième de degrés Celsius

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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Environment Canada / Environnement Canada
Atmospheric Environment Service / Service de l'environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS APRIL/AVRIL 1986

AT/À CHARLOTTETOWN (A) P.E.I.

LAT 46° 17' N LONG 63° 08' W ELEVATION/ALTITUDE: 54.5 METRES (ASL) / METRES (NMM) STANDARD TIME USED / HEURE NORMALE UTILISÉE ATLANTIC / ATLANTIQUE

DATE	TEMPERATURE / TEMPÉRATURE: MAXIMUM / MAXIMALE °C	MINIMUM / MINIMALE °C	MEAN / MOYENNE °C	DEGREE-DAYS / DEGRÉS-JOURS: HEATING / DE CHAUFFE BASE 18.0°C	GROWING / DE CROISSANCE BASE 5.0°C	REL HUMIDITY / HUMIDITÉ REL: MAXIMUM / MAXIMALE %	MINIMUM / MINIMALE %	THUNDERSTORM / ORAGE	PRECIPITATION / PRÉCIPITATIONS: RAINFALL / PLUIE (HAUTEUR) mm	SNOWFALL / NEIGE (HAUTEUR) cm	TOTAL PRECIP. / PRÉCIP. TOTALE mm	SNOW ON GROUND / NEIGE AU SOL cm	WIND / VENT: AVERAGE SPEED / VITESSE MOYENNE km/h	PREVAILING DIRECTION / DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION / VITESSE MAXIMALE ET DIRECTION km/h	BRIGHT SUNSHINE / INSOLATION EFFECTIVE HOURS / HEURES
1	10.7	1.6	6.2	11.8	1.2							2	16.6	N	28 N	6.3
2	14.7	0.6	7.7	10.3	2.7							TR	16.8	Svrl	25 S*	7.9
3	5.0	-3.0	1.0	17.0						TR	TR	TR	21.0	NW	42 NW	9.0
4	6.0	-3.2	2.4	15.6								TR	15.0	WSW	28 NNE	8.9
5	-1.8	-8.0	-4.9	22.9						TR	TR	TR	16.6	N	30 N	10.0
6	2.6	-8.0	-2.7	20.7								TR	8.8	Svrl	15 N*	8.5
7	4.8	-4.5	0.1	17.9						5.0	5.8	TR	19.3	SE	28 ESE*	4.4
8	1.2	-3.7	-1.3	19.3					2.8	6.4	10.6	10	22.5	ENE	28 ESE*	
9	3.8	0.5	2.1	15.9					7.6		7.6	6	25.0	ESE	33 E	
10	8.7	-0.3	4.2	13.8					13.7		13.7	TR	16.2	SSW	33 SSW	2.5
11	9.2	-1.0	4.1	13.9					1.4		1.4	TR	[illegible]	ESE	15 ENE*	0.6
12	5.7	0.9	3.3	14.7					5.2		5.2	TR	15.8	ESE	[illegible] ESE*	
13	7.2	-0.5	3.4	14.6					0.2		0.2	TR	[illegible]	SE	19 SE	5.0
14	13.8	-0.9	6.5	11.5	1.5							TR	[illegible]	S	15 SSE	9.7
15	7.8	-2.5	2.7	15.3								TR	16.3	N	28 NNE	9.3
16	1.6	-2.2	-0.3	18.3					36.8		36.8	TR	[illegible]	N	33 N	
17	3.7	-1.0	1.4	16.6					11.7		11.7	TR	[illegible]	[illegible]	[illegible] N	
18	4.2	-3.2	0.5	17.5								TR	[illegible]	[illegible]	28 NE*	12.6
19	6.3	-3.5	1.4	16.6								TR	[illegible]	NNE	[illegible] NNE*	9.6
20	7.7	-0.7	3.5	14.5					TR		TR	TR	[illegible]	NNE	19 NE*	
21	14.6	3.4	9.0	9.0	4.0				TR		TR	TR	9.5	S	19 S*	2.2
22	14.2	6.7	10.5	7.5	5.5				0.2		0.2	TR	[illegible]	E	[illegible] SSE*	0.1
23	9.5	1.2	5.4	12.6	0.4				19.6		19.6	TR	[illegible]	[illegible]	[illegible]	
24	8.3	2.0	5.1	12.9	0.1				2.2		2.2	TR	11.5	[illegible]	[illegible]	
25	[illegible]	[illegible]	10.2	7.8	5.2				1.4		1.4	TR	[illegible]	E	[illegible]	0.9
26	18.0	7.8	12.9	5.1	7.9				0.1		0.1		[illegible]	E	22 ENE*	2.0
27	12.4	3.6	8.0	10.0	3.0				2.1		2.1		11.7	[illegible]	[illegible] E*	0.1
28	14.0	4.0	9.0	9.0	4.0				0.6		0.6		[illegible]	[illegible]	22 SSE*	
29	8.4	1.6	5.0	13.0					TR		TR		[illegible]	NNE	28 NNE*	
30	12.8	2.2	7.5	10.5	2.5								10.6	SE	22 E*	[illegible]
31																
MEAN / MOYENNE	8.5	-0.2	4.2	TOTAL 415.6	TOTAL 38.5			TOTAL	TOTAL 106.4	TOTAL 11.4	TOTAL 120.0		15.3	PREVAILING / DOMINANTE N	MAXIMUM 42 NW	TOTAL 115.6
NORMAL / NORMALE	6.2	-1.6	2.3	471.2	14.7				53.9	27.3	81.8		20.0	N		[illegible]

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C / AU-DESSOUS DE 18°C	THIS YEAR / ANNÉE EN COURS	PREVIOUS YEAR / ANNÉE PRÉCÉDENTE	NORMAL / NORMALE	ABOVE 5°C / AU-DESSUS DE 5°C	THIS YEAR / ANNÉE EN COURS	PREVIOUS YEAR / ANNÉE PRÉCÉDENTE	NORMAL / NORMALE
TOTAL FOR MONTH / TOTAL DU MOIS	415.6	511.9	471.2	TOTAL FOR MONTH / TOTAL DU MOIS	38.5	10.4	14.7
ACCUMULATED SINCE JULY 1 / ACCUMULÉE DEPUIS LE 1er JUILLET	4333.6	4430.2	4276.0	ACCUMULATED SINCE APRIL 1 / ACCUMULÉE DEPUIS LE 1er AVRIL	38.5	10.4	14.7

	DAYS WITH TOTAL PRECIPITATION / JOURS AVEC PRÉCIPITATIONS TOTALES mm: 0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS	DAYS WITH SNOWFALL / JOURS AVEC CHUTE DE NEIGE cm: 0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS
ACCUMULATED	15	11	9	4		2	2	2		

UDC 551.506.1 ( )

Subscription Price: $1.06 monthly $10.60 per calendar year (January to December)
Prix d'abonnement: mensuel $1.06 annuel $10.60 (janvier à décembre)

*DENOTES LATER OCCURRANCE AT SAME SPEED BUT NOT NECESSARILY FROM THE SAME DIRECTION.

Canada

CHARLOTTETOWN (A) P.E.I.

COMPARATIVE RECORDS
RELEVÉS COMPARATIFS

MONTH APRIL
MOIS AVRIL

19 86

Temperature/Température – °Celsius
Precipitation/Précipitation – Millimetres (mm)
Rainfall/Hauteur de pluie – Millimetres (mm)
Snowfall/Hauteur de neige – Centimetres (cm)
Wind speed/Vitesse du vent – Kilometres per hour/par heure (km/h)
Station pressure/Pression à la station – Kilopascals (kPa)

	THIS MONTH CE MOIS-CI		PREVIOUS YEAR ANNEE PRÉCÉDENTE		NORMAL NORMALE	RECORD FOR THE MONTH RECORD POUR LE MOIS						YEARS OF RECORD ANNÉES D'OBSERVATIONS
						HIGHEST MAXIMUM ABSOLU			LOWEST MINIMUM ABSOLU			
	VALUE RELEVE	DATE	VALUE RELEVE	DATE		VALUE RELEVE	DAY JOUR	YEAR ANNÉE	VALUE RELEVE	DAY JOUR	YEAR ANNEE	
HIGHEST TEMPERATURE TEMPERATURE LA PLUS ELEVÉE	18.0	26	16.4	26		22.9	29	1983	-5.0	03	1957	43
LOWEST TEMPERATURE TEMPÉRATURE LA PLUS BASSE	-8.0	5/6	-8.8	09		11.1	24	1958	--12.2	06	1964	43
MEAN MONTHLY TEMPERATURE TEMPÉRATURE MENSUELLE MOYENNE	2.3		0.9		2.3	6.5		1951	-1.4		1967	43
TOTAL MONTHLY RAINFALL HAUTEUR TOTALE MENSUELLE DE PLUIE	106.4		15.4		53.9	121.2		1962	3.3		1973	43
TOTAL MONTHLY SNOWFALL HAUTEUR TOTALE MENSUELLE DE NEIGE	11.4		24.9		27.3	110.5		1972	TR		1951	43
TOTAL MONTHLY PRECIPITATION PRÉCIPITATION TOTALE MENSUELLE	120.0		39.1		81.8	162.3		1946	14.7		1966	43
NO OF DAYS WITH MEASURABLE PRECIPITATION NOMBRE DE JOURS AVEC PRÉCIPITATION MESURABLE	15		13		13	21		1974	5		1960	43
GREATEST RAINFALL IN ONE DAY HAUTEUR DE PLUIE MAXIMALE EN UNE JOURNÉE	36.8	16	6.2	06		58.7	01	1962				43
GREATEST SNOWFALL IN ONE DAY HAUTEUR DE NEIGE MAXIMALE EN UNE JOURNÉE	6.4	07	9.6	08		38.1	15	1946				43
GREATEST PRECIPITATION IN ONE DAY PRÉCIPITATION MAXIMALE EN UNE JOURNÉE	36.8	16	11.6	08		58.7	01	1962				43
MAXIMUM RAINFALL RECORDED IN: HAUTEUR DE PLUIE MAXIMALE ENREGISTRÉE EN:												
5 MINUTES												
10 MINUTES												
15 MINUTES												
30 MINUTES												
60 MINUTES												
24 CONSECUTIVE HOURS HEURES CONSECUTIVES												
MEAN WIND SPEED (km/h) VITESSE MOYENNE DU VENT (km/h)	15.3		17.1		20.3	25.2		1978	15.3		1972	31
MAXIMUM SPEED (1 min.) (km/h) VITESSE MAXIMALE (1 min.) (km/h)	42 NW	03	41 W	18		82 ESE		1962	[illegible]		[illegible]	31
MAXIMUM GUST SPEED (km/h) POINTE DU VENT MAXIMALE (km/h)	74 SSW	17	83 SSW			121 NE		1963	64 ESE		[illegible]	31
TOTAL HOURS OF SUNSHINE TOTAL DES HEURES INSOLATION	116		172		157	217		1947	99		1961	72
MEAN STATION PRESSURE (kPa) PRESSION MOYENNE A LA STATION (kPa)	100.69		100.53		100.60	101.09		1962	99.90		1963	25
GREATEST STATION PRESSURE (kPa) PRESSION MAXIMALE A LA STATION (kPa)	102.58	05	102.79	14		103.25	07	1983				10
LEAST STATION PRESSURE (kPa) PRESSION MINIMALE A LA STATION (kPa)	99.57	12	98.14	17					98.92	07	1982	10

CLIMATOLOGICAL DATA FOR THE PAST 10 YEARS
DONNÉES CLIMATOLOGIQUES POUR LES 10 DERNIÈRE ANNÉES

YEAR ANNÉE	MAXIMUM TEMP TEMP MAXIMALE	MINIMUM TEMP TEMP MINIMALE	MEAN TEMP TEMP MOYENNE	RAINFALL HAUTEUR DE PLUIE	SNOWFALL HAUTEUR DE NEIGE	TOTAL PRECIP PRECIP TOTALE	MEAN WINDSPEED VITESSE MOYENNE DES VENTS	MAXIMUM WINDSPEED VITESSE MAXIMALE DES VENTS	HOURS SUNSHINE HEURES INSOLATION	HEATING DEGREE DAYS DEGRES-JOURS DE CHALEUR	GROWING DEGREE DAYS DEGRES-JOURS DE CROISSANCE	
1976	17.2	-6.7	3.3	62.2	13.7	78.2	18.7	54 NE	151	440.2		14
1977	19.4	-10.0	1.9	29.5	40.0	69.8	21.7	72 W	191	487.4	18.8	13
1978	13.1	-9.8	0.7	41.4	57.0	107.5	25.2	45 NW	143	521.8	3.2	15
1979	21.2	-4.6	3.4	18.8	36.0	59.9	20.3	37 N	163	438.4	43.0	12
1980	18.2	-5.5	4.3	84.3	0.2	84.5	24.5	52 SE	163	410.8	27.2	12
1981	19.2	-9.6	4.1	90.9	25.2	116.2	20.7	46 S	126	418.8	45.4	20
1982	21.1	-8.7	2.7	78.6	31.9	121.2	24.0	50 NNW	150	460.4	30.3	15
1983	22.9	-3.1	4.5	103.5	27.3	109.7	20.1	56 NE	109	379.5	60.2	12
1984	16.8	-6.6	2.2	102.0	40.2	146.5	23.0	65 N	151	471.7	13.8	17
1985	16.4	-8.8	0.9	15.4	24.9	39.1	17.1	41 W	172	511.9	10.4	13
1986	18.0	-8.0	2.3	106.4	11.4	120.0	15.3	42 NW	116	415.6	35.5	15

DRY-BULB TEMPERATURE SUMMARY*
SOMMAIRE DES TEMPÉRATURES DU THERMOMÈTRE SEC*

MONTH APRIL
MOIS AVRIL

19 86

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	54	42	38	31	27	28	19	38	42	62	68	75	76	90	91	95	92	100	89	76	79	76	72	78
2	80	71	60	59	52	48	48	61	62	84	102	117	130	141	138	140	115	90	69	58	52	47	40	35
3	06	07	10	14	12	14	22	28	22	08	28	26	36	37	42	42	37	32	28	06	-14	-19	-18	-28
4	-18	-24	-28	-29	-28	-24	-32	-22	-01	27	35	44	67	23	58	55	52	44	19	01	-12	-19	-24	-28
5	-29	-27	-30	-32	-36	-37	-38	-37	-35	-32	-30	-27	-33	-29	-32	-35	-36	-41	-44	-60	-56	-54	-60	-70
6	-69	-74	-75	-73	-72	-73	-72	-53	-34	-08	-04	10	12	16	21	24	20	19	05	-10	-23	-26	-31	-34
7	-33	-32	-34	-44	-32	-38	-34	-27	-14	-03	09	24	32	34	36	42	43	36	23	00	-08	-14	-17	-27
8	-40	-35	-34	-34	-31	-35	-32	-26	-24	-20	-14	-11	-08	-05	00	03	07	08	09	08	09	08	08	07
9	06	06	05	07	08	08	08	05	08	13	13	14	16	17	18	15	15	16	26	30	32	34	34	33
10	31	26	24	26	28	40	39	43	62	48	16	42	50	43	52	50	57	51	54	41	32	14	24	25
11	05	08	-02	-06	-09	-05	-07	12	24	32	52	76	65	65	57	68	43	36	30	20	14	18	18	16
12	21	25	22	27	29	23	17	18	22	30	32	35	36	40	47	49	54	54	40	30	21	26	22	18
13	13	11	09	05	00	07	08	13	13	17	22	29	25	41	49	63	66	70	63	40	32	22	08	04
14	-05	-01	-02	-06	-06	-07	-06	-02	27	68	76	90	107	109	116	120	126	128	113	92	78	49	40	36
15	28	00	00	-01	-08	-17	-20	-04	-03	29	46	68	68	73	48	24	08	02	-02	-03	-02	-06	-11	-14
16	-22	-23	-20	-20	-20	-18	-16	-06	-01	04	08	10	10	08	08	08	10	10	11	11	12	12	12	12
17	12	12	12	12	10	10	10	10	14	15	17	26	30	34	32	30	30	28	25	22	15	15	03	-02
18	-02	-04	-10	-21	-27	-18	-06	02	08	21	33	36	33	27	28	23	20	16	05	-09	-14	-18	-19	-22
19	-27	-29	-32	-32	-33	-30	-25	-12	02	18	30	34	44	51	56	45	26	24	20	02	-04	-08	-10	-39
20	-07	-28	-07	-03	00	02	06	05	08	14	25	33	41	62	69	72	62	64	58	51	48	36	35	32
21	36	37	34	35	37	37	37	43	51	54	52	64	87	109	118	132	141	137	106	95	104	93	86	91
22	81	83	76	76	69	70	69	65	84	101	111	120	128	125	120	140	132	121	121	110	110	111	110	100
23	96	91	93	71	48	43	43	46	52	38	25	28	24	28	26	24	20	18	17	12	12	14	20	20
24	21	20	29	35	37	48	52	43	40	46	58	70	83	67	54	49	52	38	38	28	26	25	21	28
25	24	38	41	51	42	54	70	105	112	120	124	134	140	161	166	160	150	136	135	127	114	110	105	114
26	120	112	107	100	94	94	84	96	101	113	128	150	150	175	157	154	133	141	130	121	117	84	80	43
27	77	83	85	78	79	70	40	54	62	81	97	109	122	95	117	114	120	113	90	85	62	60	45	42
28	39	41	44	42	43	44	42	50	56	74	91	104	121	123	126	138	134	117	113	106	103	102	100	100
29	88	80	78	77	71	79	52	80	69	69	52	47	51	41	44	35	38	27	26	20	19	17	18	12
30	18	21	22	24	28	30	32	37	44	49	58	67	78	92	118	117	119	124	132	92	80	80	81	78
31																								

*Temperatures in tenths of degrees Celsius – Températures en dixième de degrés Celsius

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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CHARLOTTETOWN (A) P.E.I.

WIND SUMMARY (Kilometres per hour)
SOMMAIRE DES VENTS (Kilomètres par heure)

MONTH
MOIS

19

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Peak Gust Rafale maximum	Hour Heure
1	W 28	W 22	W 19	W 19	W 22	W 19	WNW 11	NW 9	WNW 15	SSW 13	C	S 13	SE 13	S 15	SW 15	WSW 15	WSW 15	SW 22	SW 19	SW 15	SW 19	SW 19	SW 19	SSW 22	W 37	1700
2	SSW 19	SSW 22	SSW 22	S 22	S 28	SSW 28	S 22	S 22	S 22	S 24	SSW 22	SW 24	WSW 19	W 19	WNW 29	N 13	N 22	N 19	N 11	N 9	N 9	C	C	C	W 37	1400
3	NW 6	C	W 9	NW 15	WNW 13	WNW 15	WNW 22	NW 22	NW 28	NW 42	NW 29	NW 33	NW 41	WNW 33	NNW 32	NW 29	NW 28	NW 33	NNW 19	N 9	NNW 9	NW 9	NNW 7	NW 9	NW 65	0900
4	NW 6	WNW 6	WSW 9	W 13	WSW 9	WSW 9	SW 9	SSW 9	WSW 13	WSW 9	SSW 19	WSW 22	W 19	W 22	N 15	N 22	N 22	N 19	NE 19	NE 19	NNE 29	NNE 25	NE 22	NE 15	NNE 37	2100
5	NNE 9	N 15	N 19	N 15	N 15	N 19	NNW 15	N 22	N 30	N 28	N 19	N 28	NNW 19	NW 19	NW 19	NNW 19	NW 19	NW 19	NNW 19	NNW 11	NNE 7	C	WSW 7	W 7	N 39	0900
6	NW 9	NW 7	W 7	W 7	W 6	C	WSW 9	WSW 9	W 9	WSW 11	W 7	W 9	N 15	WSW 7	NW 9	N 15	NNW 9	NE 13	ENE 9	NE 9	ENE 9	SE 9	SE 9	SE 9		
7	SE 11	SE 9	SE 9	SE 9	SE 9	SE 11	ESE 19	ESE 19	SE 19	SE 19	SE 22	SE 22	ESE 22	ESE 22	ESE 22	SE 26	SE 22	ESE 19	ESE 19	ESE 28	SE 22	ESE 23	ESE 28	ESE 28	ESE 37	1400
8	ESE 22	ESE 22	ESE 22	ESE 28	ESE 29	ESE 22	ESE 19	ESE 19	ESE 22	ESE 22	ESE 28	ESE 28	E 28	ESE 28	E 19	ESE 19	ESE 22	ESE 22	ESE 22	ESE 24	ESE 22	ESE 28	ESE 24	SE 22	ESE 52	0400
9	ESE 28	ESE 28	ESE 28	ESE 28	ESE 28	SE 28	ESE 28	ESE 28	ESE 28	ESE 28	ESE 28	ESE 28	ESE 26	ESE 28	SE 25	E 33	E 33	ESE 28	ESE 28	E 22	E 24	SE 19	E 15	SSE 11	ESE 61	1600
10	E 19	E 6	NE 9	NE 7	ENE 9	ENE 19	ENE 22	E 28	E 28	S 28	SSW 33	SSW 28	SW 28	S 22	SW 24	S 24	SSW 22	SW 22	SSW 19	SSW 7	C	ESE 7	SE 15	SE 7	SSW 56	1200
11	ESE 9	ESE 9	E 7	SE 6	SE 6	ESE 6	C	C	ENE 9	ENE 15	E 15	E 15	ESE 13	SE 7	ESE 6	NE 9	NNE 15	N 4	N 7	N 7	N 9	NE 9	E 9	E 9		
12	E 9	E 15	ESE 15	ESE 22	ESE 15	ESE 15	E 22	ESE 15	ESE 19	E 26	E 22	ENE 22	ESE 28	ESE 28	ESE 28	SE 26	SE 22	S 19	SSW 15	SW 11	SW 11	SW 15	S 15	S 15	ESE 41	1400
13	SSE 15	SSE 15	SSE 15	SSE 15	SE 11	SE 13	SE 15	SE 15	SE 19	SE 11	SE 11	SE 11	SE 11	ESE 13	SE 9	SE 13	S 15	SSE 9	SSE 9	SSE 11	ESE 15	E 11	ESE 7	S 7		
14	C	C	SSE 4	C	S 4	C	C	C	C	C	C	S 11	SSE 9	S 15	SSE 15	S 9	S 7	SE 7	ENE 9	C	ESE 7	SE 7	ESE 11	C		
15	C	NNW 9	N 9	N 9	N 6	NNW 11	NNW 9	N 19	N 19	N 15	NNE 22	NNE 22	NNE 19	N 22	N 26	N 19	NNE 22	NNE 26	NNE 24	N 26	N 22	N 22	N 15	N 19		
16	N 19	N 22	N 28	N 28	N 22	N 22	N 28	N 19	N 28	N 22	N 22	N 26	N 26	N 28	NNW 28	N 28	N 33	N 28	N 28	N 28	N 28	N 28	N 28	N 28	N 56	1600
17	N 28	N 28	NNW 22	N 28	NNW 28	N 30	N 28	N 22	N 30	NNW 32	N 35	N 28	N 28	N 33	N 30	N 22	N 22	N 28	N 22	NNE 19	NNE 19	N 13	N 6	N 9	N 56	1000
18	N 15	NNE 9	N 9	N 9	N 15	N 15	NNE 11	NE 15	ENE 22	NE 22	NE 28	NE 25	NE 24	NE 22	NNE 22	NE 19	NE 28	NNE 28	N 25	NNE 22	NE 19	NNE 15	NE 15	NE 15	NE 41	1600
19	[illegible]	[illegible]	NNE 15	NE 15	NNE 15	NNE 19	NNE 19	NNE 19	NE 15	NNE 15	NNE 19	NE 22	NNE 19	NE 13	NNE 22	NNE 28	NNE 28	NNE 22	NNE 19	NNE 15	NNE 13	NNE 11	NNE 13	NE 13		
20	NNE 13	N 9	NE 19	NNE 13	NNE 13	NNE 13	N 19	NNE 19	NNE 19	NNE 19	NNE 15	NE 11	NE 11	N 7	C	SSE 7	SSW 6	WSW 6	SSE 7	ESE 11	C	C	C	C		
21	C	ESE 7	SSE 6	S 6	S 6	S 7	C	C	SSE 9	S 9	S 11	S 7	SSW 15	S 11	S 6	SSE 15	SSE 15	WSW 15	S 11	S 6	S 11	S 15	S 15	SSE 19		
22	SSE 15	SSE 19	S 19	S 24	S 22	SSE 19	S 19	SSE 19	SE 22	SSE 19	SSE 25	SSE 22	SSE 22	SSE 22	ESE 24	S 24	S 22	S 22	S 19	S 19	S 15	S 15	SSW 15	S 15	S 35	1500
23	SSW 9	SSW 6	C	[illegible] 11	[illegible] 13	[illegible] 11	[illegible] 11	[illegible] 13	[illegible] 9	[illegible] 15	[illegible] 26	[illegible] 15	[illegible] 19	[illegible] 28	[illegible] 22	[illegible] 28	[illegible] 26	[illegible] 26	[illegible] 19	[illegible] 22	[illegible] 22	[illegible] 19	[illegible] 9	[illegible] 9	[illegible] 30	1800
24	[illegible] 9	[illegible] 6	[illegible] 6	[illegible] 7	[illegible] 7	C	C	[illegible] 9	[illegible] 11	[illegible] 11	[illegible] 15	[illegible] 11	[illegible] 15	[illegible] 15	[illegible] 19	[illegible] 22	[illegible] 19	[illegible] 15	[illegible] 9	[illegible] 19	[illegible] 13	[illegible] 9	[illegible] 9	[illegible] 9		
25	[illegible] 11	[illegible] 11	[illegible] 9	N 9	C	C	NE 6	E 9	E 11	E 15	E 11	E 19	E 11	E 15	E 22	E 22	ESE 15	[illegible] 9	[illegible] 9	NE 15	NE 13	NE 9	NE 9	E 6		
26	E 11	E 15	E 7	E 15	E 11	ENE 9	E 7	E 15	E 11	ENE 9	E 9	E 19	NNE 13	NNE 9	E 22	NNE 19	E 13	E 22	E 22	E 13	E 19	NE 11	NNE 11	NE 9		
27	[illegible] 9	E 11	E 7	E 9	ENE 9	NNE 9	[illegible] 15	[illegible] 11	[illegible] 9	[illegible] 13	[illegible] 9	NNE 9	ENE 9	[illegible] 13	[illegible] 11	N 11	[illegible] 15	NNE 19	[illegible] 15	[illegible] 13	[illegible] 11	[illegible] 13	[illegible] 9	[illegible] 13		
28	NNW 9	[illegible] 9	C	[illegible] 9	[illegible] 9	[illegible] 7	NNW 9	NNW 9	[illegible] 6	NNW 6	C	C	C	[illegible] 9	C	SSE 11	SSE 7	[illegible] 11	NNE 7	C	C	C	SSE 7	S 9		
29	S 9	SSW 9	C	S 6	C	C	[illegible] 9	[illegible] 15	[illegible] 19	[illegible] 9	NNE 22	NNE 19	NE 19	NE 22	NNE 25	NNE 25	NNE 22	NNE 26	NE 19	NNE 15	NNE 11	[illegible] 11	NE 9	C		
30	C	C	C	C	C	C	C	ESE 9	ESE 9	ESE 13	SSE 13	SSE 19	SSE 13	S 22	S 22	SSE 15	SE 15	SSE 19	SE 11	SE 11	SE 11	SE 15	SE 19	S 19		
31																										

On indique un vent d'ouest par la lettre 'W'.

*Indicates later occurrence of same speed
*Indique des données postérieures de la même vitesse.

Environment Canada / Environnement Canada
Atmospheric Environment Service / Service de l'environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS JUNE/JUIN 19 86

AT/À CHARLOTTETOWN (A), PRINCE EDWARD ISLAND, ILE DU PRINCE EDOUARD

LAT [illegible] 17'N LONG 63° 08'W ELEVATION/ALTITUDE 54.5 METRES (ASL) / METRES (NMM) STANDARD TIME USED / HEURE NORMALE UTILISEE ATLANTIQUE

DATE	TEMPERATURE MAXIMUM MAXIMALE °C	TEMPERATURE MINIMUM MINIMALE °C	TEMPERATURE MEAN MOYENNE °C	DEGREE-DAYS HEATING DE CHAUFFE BASE 18.0°C	DEGREE-DAYS GROWING DE CROISSANCE BASE 5.0°C	REL. HUMIDITY MAXIMUM MAXIMALE %	REL. HUMIDITY MINIMUM MINIMALE %	THUNDERSTORM ORAGE	RAINFALL PLUIE (HAUTEUR) mm	SNOWFALL NEIGE (HAUTEUR) cm	TOTAL PRECIP. PRÉCIP. TOTALE mm	SNOW ON GROUND NEIGE AU SOL cm	WIND AVERAGE SPEED VITESSE MOYENNE km/h	WIND PREVAILING DIRECTION DIRECTION DOMINANTE	WIND MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION km/h	BRIGHT SUNSHINE INSOLATION EFFECTIVE HOURS HEURES
1	[illegible]	7.2	12.5	5.5	7.5				1.4		1.4		[illegible]	S	28 SW*	1.5
2	14.2	6.4	10.4	7.6	5.4				15.2		15.2		16.5	N	24 N*	0.0
3	10.2	5.2	7.7	10.3	2.7				1.0		1.0		16.2	NNW	26 NNW	6.3
4	17.5	5.3	11.4	6.6	6.4								19.7	SW	33 SW	1.4
5	15.4	8.6	12.0	6.0	7.0				1.2		1.2		12.2	SW	22 SW*	0.1
6	[illegible]	8.1	11.4	6.6	6.4								11.1	NE	19 NE*	11.9
7	21.4	6.0	13.7	4.3	8.7								9.7	SE	22 S	12.3
8	[illegible]	10.0	14.7	3.3	9.7				22.0		22.0		23.1	SW	28 WSW*	0.0
9	16.4	11.0	13.7	4.3	8.7								25.5	NNW	33 NW*	12.5
10	21.2	10.7	16.0	2.0	11.0								[illegible]	WNW	28 WNW*	10.5
11	14.6	2.6	8.6	9.4	3.6								15.8	WSW	28 [illegible]	3.1
12	14.0	2.1	8.1	9.9	3.1								10.6	N	15 NE*	14.5
13	[illegible]	4.5	10.5	7.5	5.5				1.6		1.6		15.7	SE	28 SSE	5.1
14	15.0	8.4	11.7	6.3	6.7				2.0		2.0		10.5	N	19 ESE*	1.9
15	25.2	9.5	17.4	0.6	12.4				0.6		0.6		16.5	[illegible]	28 SW*	12.1
16	25.6	8.4	17.0	1.0	12.0								15.8	S	28 S*	9.2
17	18.9	11.3	15.1	2.9	10.1				3.4		3.4		24.2	S	33 S*	6.7
18	18.3	10.2	14.3	3.7	9.3								20.6	WSW	28 WSW	13.9
19	17.5	9.2	13.4	4.6	8.4								8.5	N	22 WNW	11.3
20	22.1	7.0	14.6	3.4	9.6								11.3	NE	22 NE*	13.9
21	18.0	[illegible]	11.6	6.4	6.6								10.3	N	19 N*	14.8
22	[illegible]	5.7	14.1	3.9	9.1								8.5	ESE	15 S	[illegible]
23	23.2	[illegible]	[illegible]	0.0	13.6			1	4.2		4.2		17.3	S	28 S	5.2
24	[illegible]	[illegible]	[illegible]	0.0	15.4			1	4.0		4.0		15.6	WSW	28 WSW	8.9
25	[illegible]	[illegible]	12.4	5.6	7.4				0.4		0.4		23.5	S/SW	37 SW	4.0
26	13.3	[illegible]	10.4	7.6	5.4				TR		TR		13.9	W	25 WNW	3.0
27	[illegible]	[illegible]	13.1	4.9	8.1				TR		TR		12.4	W	19 WNW*	11.1
28	17.1	11.0	14.1	3.9	9.1				8.8		8.8		18.4	S	25 S	0.0
29	21.2	12.0	16.6	1.4	11.6			1	7.6		7.6		11.4	S	26 S	4.4
30	18.8	10.5	14.7	3.3	9.7				0.4		0.4		14.0	NNW	24 WNW	8.9
31																
MEAN MOYENNE	18.5	8.1	13.3	TOTAL 143.2	TOTAL 249.8			TOTAL 3	TOTAL 73.8	TOTAL 0.0	TOTAL 73.8		15.8	PREVAILING S DOMINANTE	MAXIMUM 37 SW	TOTAL [illegible]
NORMAL NORMALE	19.4	9.5	14.5	117.1	283.6				79.9		79.9		17.7	WSW		220.8

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C AU-DESSOUS DE 18°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE	ABOVE 5°C AU-DESSUS DE 5°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE
TOTAL FOR MONTH TOTAL DU MOIS	[illegible]	[illegible]	117.1	TOTAL FOR MONTH TOTAL DU MOIS	249.8	255.9	283.6
ACCUMULATED SINCE JULY 1 ACCUMULEE DEPUIS LE 1er JUILLET	[illegible]	[illegible]	[illegible]	ACCUMULATED SINCE APRIL 1 ACCUMULÉE DEPUIS LE 1er AVRIL	416.5	389.7	417.0

DAYS WITH TOTAL PRECIPITATION / JOURS AVEC PRÉCIPITATIONS TOTALES mm					DAYS WITH SNOWFALL / JOURS AVEC CHUTE DE NEIGE cm				
0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	80.0 OR MORE – OU PLUS	0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	80.0 OR MORE – OU PLUS
15	12	6	2	-	-	-	-	-	-

UDC 551.506.1 (

*DENOTES LATER OCCURRENCE AT SAME SPEED BUT NOT NECESSARILY FROM THE SAME DIRECTION

Canada

CHARLOTTETOWN (A) P.E.I.

COMPARATIVE RECORDS
RELEVES COMPARATIFS

MONTH / MOIS JUNE JUIN 19 86

Temperature/Température – °Celsius
Precipitation/Précipitation – Millimetres (mm)
Rainfall/Hauteur de pluie – Millimetres (mm)
Snowfall/Hauteur de neige – Centimetres (cm)
Wind speed/Vitesse du vent – Kilometres per hour/par heure (km/h)
Station pressure/Pression à la station – Kilopascals (kPa)

	THIS MONTH CE MOIS-CI		PREVIOUS YEAR ANNÉE PRÉCÉDENTE		NORMAL NORMALE	RECORD FOR THE MONTH RECORD POUR LE MOIS						YEARS OF RECORD ANNÉES D'OBSERVATIONS
						HIGHEST MAXIMUM ABSOLU			LOWEST MINIMUM ABSOLU			
	VALUE RELEVÉ	DATE	VALUE RELEVÉ	DATE		VALUE RELEVÉ	DAY JOUR	YEAR ANNÉE	VALUE RELEVÉ	DAY JOUR	YEAR ANNÉE	
HIGHEST TEMPERATURE TEMPERATURE LA PLUS ELEVEE	26.2	24	23.0	16		32.2	29	[illegible]	16.9	25	1944	43
LOWEST TEMPERATURE TEMPERATURE LA PLUS BASSE	2.1	12	5.5	05		6.7	08	1975	-1.1	08	1947	43
MEAN MONTHLY TEMPERATURE TEMPERATURE MENSUELLE MOYENNE	13.3		13.5			16.6		1961	12.3		1943	43
TOTAL MONTHLY RAINFALL HAUTEUR TOTALE MENSUELLE DE PLUIE	73.8		167.8		79.9	197.7		1981	19.3		1979	43
TOTAL MONTHLY SNOWFALL HAUTEUR TOTALE MENSUELLE DE NEIGE												
TOTAL MONTHLY PRECIPITATION PRECIPITATION TOTALE MENSUELLE	73.8		167.2		79.9	197.7		1981	19.3		1979	43
NO OF DAYS WITH MEASURABLE PRECIPITATION NOMBRE DE JOURS AVEC PRECIPITATION MESURABLE	15		17		12	19		1981	6		1979	43
GREATEST RAINFALL IN ONE DAY HAUTEUR DE PLUIE MAXIMALE EN UNE JOURNEE	22.0	08	57.8	06		57.2	06	1985				43
GREATEST SNOWFALL IN ONE DAY HAUTEUR DE NEIGE MAXIMALE EN UNE JOURNEE												
GREATEST PRECIPITATION IN ONE DAY PRECIPITATION MAXIMALE EN UNE JOURNEE	22.0	08	57.8	06		57.6	06	1985				43
MAXIMUM RAINFALL RECORDED IN HAUTEUR DE PLUIE MAXIMALE ENREGISTREE EN												
5 MINUTES												
10 MINUTES												
15 MINUTES												
30 MINUTES												
60 MINUTES												
24 CONSECUTIVE HOURS HEURES CONSECUTIVES												
MEAN WIND SPEED (km/h) VITESSE MOYENNE DU VENT (km/h)	15.8		17.5		17.7	20.4		1964	14.5		1957	31
MAXIMUM SPEED (1 min) (km/h) VITESSE MAXIMALE (1 min) (km/h)	37 SW	25	33 SSE	01		64 ENE		1973	33 SSE	01	1985	31
MAXIMUM GUST SPEED (km/h) POINTE DU VENT MAXIMALE (km/h)	65 SW	04	56 WNW	09		93 NNE		1959	52 N		1969	31
TOTAL HOURS OF SUNSHINE TOTAL DES HEURES INSOLATION	221.8		175.0		220.8	279		1946	131		1945	71
MEAN STATION PRESSURE (kPa) PRESSION MOYENNE A LA STATION (kPa)	100.38		100.46		100.62	101.07		1967	100.32		1981	25
GREATEST STATION PRESSURE (kPa) PRESSION MAXIMALE A LA STATION (kPa)	101.59	12	101.94	27		102.48	14	1977				10
LEAST STATION PRESSURE (kPa) PRESSION MINIMALE A LA STATION (kPa)	96.83	08	99.04	10					96.78	10	1981	10

CLIMATOLOGICAL DATA FOR THE PAST 10 YEARS
DONNÉES CLIMATOLOGIQUES POUR LES 10 DERNIÈRE ANNEES

YEAR ANNÉE	MAXIMUM TEMP TEMP MAXIMALE	MINIMUM TEMP TEMP MINIMALE	MEAN TEMP TEMP MOYENNE	RAINFALL HAUTEUR DE PLUIE	SNOWFALL HAUTEUR DE NEIGE	TOTAL PRECIP PRECIP TOTALE	MEAN WINDSPEED VITESSE MOYENNE DES VENTS	MAXIMUM WINDSPEED VITESSE MAXIMALE DES VENTS	HOURS SUNSHINE HEURES INSOLATION	HEATING DEGREE DAYS DEGRES-JOURS DE CHAUFFE	GROWING DEGREE DAYS DEGRES-JOURS DE CROISSANCE	PRECIP DAYS
1976	23.9	0.6	15.9	78.7		78.7	17.4	56 NE		89.6		10
1977	27.8	4.6	14.1	128.9		128.9	16.8	56 SW	162	122.7	272.8	17
1978	27.2	1.5	14.8	110.0		110.0	19.1	37 N	228	102.1	294.1	13
1979	29.8	5.7	15.7	19.3		19.3	18.7	37 SS	259	78.5	323.7	6
1980	30.1	4.3	13.8	94.0		94.0	19.8	47 SW	228	137.8	264.5	10
1981	29.2	6.1	14.8	197.7		197.7	14.9	41 N	235	125.5	291.2	16
1982	[illegible]	[illegible]	13.4	116.1		116.1	14.6	41 S	224	137.6	252.6	12
1983	[illegible]	[illegible]	15.2	38.0		38.0	17.9	37 S	.232	93.3	377.0	8
1984	[illegible]	1.3	[illegible]	125.8		125.8	16.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1985	[illegible]	5.5	[illegible]	167.8		167.2	17.5	33 SSE	175	134.9	255.9	17
1986	[illegible]	2.1	13.3	73.8		73.8	15.8	37 SW	225	113.2	249.6	15

CHARLOTTETOWN (A) P.E.I.

DRY-BULB TEMPERATURE SUMMARY*
SOMMAIRE DES TEMPERATURES DU THERMOMÈTRE SEC*

MONTH / MOIS JUNE / JUIN

19 86

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	90	83	84	72	81	94	100	105	112	125	142	106	165	174	166	137	136	141	138	136	134	134	150	148
2	152	145	142	138	92	84	63	80	76	77	76	74	70	77	71	69	71	68	68	68	64	64	64	67
3	67	66	64	58	63	54	66	87	80	83	90	72	67	70	84	90	94	98	101	97	84	78	73	60
4	[illegible]	63	56	53	54	53	78	83	100	103	124	137	152	157	150	171	170	158	145	133	124	122	123	124
5	121	114	117	112	112	112	110	110	113	116	118	119	126	138	146	142	152	151	146	140	130	123	115	115
6	[illegible]	92	86	[illegible]	73	76	93	112	125	139	157	160	145	137	136	144	144	138	138	124	110	95	92	84
7	[illegible]	73	81	64	60	62	78	103	120	136	141	156	171	180	188	206	209	210	102	174	170	140	140	123
8	113	105	102	100	112	116	118	116	120	129	142	147	162	192	192	191	186	188	184	179	180	182	182	[illegible]
9	112	159	157	157	159	150	140	127	130	132	144	142	152	152	150	151	162	156	160	155	144	140	122	110
10	113	113	110	117	110	110	114	118	131	136	142	155	161	173	187	210	202	200	187	164	171	172	173	108
11	160	153	145	138	132	130	130	126	118	112	101	89	84	93	89	83	90	102	109	90	79	51	47	60
12	43	28	32	21	36	30	64	94	107	118	125	125	124	126	130	132	123	116	109	101	88	72	70	67
13	57	53	58	47	52	49	64	93	97	105	118	133	150	156	155	146	138	144	120	106	101	101	98	93
14	90	87	86	84	88	88	92	98	103	107	119	112	120	124	122	130	129	134	144	144	129	120	109	[illegible]
15	100	[illegible]	107	116	113	107	120	141	160	171	183	200	216	222	242	252	247	242	231	200	190	154	137	[illegible]
16	[illegible]	110	98	93	112	114	127	146	160	181	200	210	226	253	222	227	237	224	210	192	192	192	182	[illegible]
17	171	180	182	175	172	179	172	167	167	172	166	158	160	174	186	170	164	160	154	149	136	127	120	[illegible]
18	[illegible]	120	113	110	107	105	111	120	131	130	145	154	170	163	176	180	178	178	162	150	136	104	110	113
19	[illegible]	108	109	104	112	106	110	119	138	156	149	149	168	156	154	154	160	158	160	154	141	131	123	105
20	110	96	94	90	92	72	96	120	141	164	174	178	189	202	210	218	202	164	152	151	136	116	107	105
21	[illegible]	[illegible]	77	73	59	54	81	120	135	143	152	158	164	176	167	160	156	160	148	140	124	100	88	83
22	[illegible]	[illegible]	61	62	58	58	94	115	138	150	170	183	200	200	206	219	220	221	216	201	181	159	143	[illegible]
23	[illegible]	144	148	152	150	150	156	159	160	162	180	218	[illegible]	202	209	226	227	224	208	180	161	156	149	[illegible]
24	[illegible]	150	150	150	149	144	143	152	160	171	192	214	230	250	246	262	262	257	243	222	219	203	187	[illegible]
25	[illegible]	163	160	158	158	163	170	163	154	152	146	156	165	163	166	163	159	152	146	140	133	123	114	118
26	107	80	80	83	80	80	94	110	108	112	120	120	120	116	116	122	112	122	118	115	107	105	105	[illegible]
27	[illegible]	[illegible]	85	74	75	75	104	124	140	153	162	168	176	177	155	186	182	170	170	164	154	147	140	[illegible]
28	[illegible]	130	125	121	114	112	119	124	122	124	132	140	[illegible]	152	156	163	167	170	166	163	162	153	143	[illegible]
29	[illegible]	117	[illegible]	123	135	137	138	[illegible]	150	162	168	180	155	194	199	206	175	168	193	168	150	139	135	[illegible]
30	[illegible]	[illegible]	130	136	139	142	150	163	165	175	178	172	165	155	153	157	161	158	141	123	106	112	109	[illegible]
31																								

*Temperatures in tenths of degree Celsius – Températures en dixième de degré Celsius

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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CHARLOTTETOWN (A) P.E.I.

WIND SUMMARY (Kilometres per hour)
SOMMAIRE DES VENTS (Kilomètres par heure)

MONTH / MOIS: JUNE / JUIN 1986

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Peak Gust Rafale maximum	Hour Heure
1	SE 7	ESE 7	ESE 11	SSE 9	S 11	S 11	S 11	S 9	SW 13	SSE 9	S 13	SSE 22	SSE 19	S 22	S 28	S 24	SSE 28	S 26	S 28	S 22	S 24	SSW 19	SSW 19	S 19	S 46	1600
2	SSW 19	SSW 9	WSW 6	WNW 15	W 19	N 19	NNE 15	N 22	N 19	NNE 19	NNE 19	NNE 22	N 24	NE 24	N 15	NNE 19	N 22	N 22	N 19	N 13	N 11	NNW 7	NNW 7	NNW 9		
3	N 9	NNW 9	NW 9	WNW 15	WNW 13	NW 19	WNW 19	WNW 24	NNW 19	NW 22	NW 22	NNW 22	N 22	N 22	N 22	NNW 22	NNW 22	NNE 24	NNW 15	NW 9	NW 4	C	SSW 11	WSW 9	N 37	1200
4	WSW 9	WSW 11	SW 7	SW 9	SW 11	SW 13	SW 13	SW 13	SW 22	SW 19	SW 28	SW 26	SW 30	SW 28	SW 28	SW 33	WSW 22	SW 19	SW 19	SW 22	WSW 28	WSW 19	WSW 24	WSW 22	SW 65	2300
5	WSW 22	SW 22	SW 22	SW 19	WSW 19	WSW 19	SW 22	SW 19	SW 19	SW 19	WSW 15	SW 15	SW 9	SW 9	SW 9	W 6	C	C	C	S 9	S 9	SW 6	C	WSW 4		
6	NNW 9	N 13	NNE 13	NE 13	NE 9	C	S 7	C	E 6	E 9	C	N 15	N 19	NE 15	NE 19	NE 19	NE 15	ENE 19	NE 15	NE 11	NE 11	E 7	SE 11	SE 11		
7	ESE 11	E 7	C	ESE 4	E 4	E 4	ESE 4	SE 6	SE 6	SE 15	S 9	S 9	SW 9	SW 6	SE 6	E 6	SE 11	SE 15	SE 11	SE 11	SE 15	S 19	S 22	S 22		
8	S 19	S 15	SE 11	SE 19	SE 19	SE 22	SE 22	SE 19	SE 19	SE 19	S 22	S 22	SSW 26	SW 26	WSW 28	SW 25	SW 28	SW 28	SW 28	WSW 28	SW 25	SW 28	SW 28	SW 22	WSW 46	1600
9	SW 28	W 22	W 22	W 19	W 15	W 15	WNW 19	WNW 19	WNW 26	WNW 28	WNW 26	W 28	WNW 28	WNW 26	W 28	W 28	W 33	W 33	WNW 33	W 33	WNW 28	WNW 28	WNW 25	WNW 19	W 59	1800
10	W 22	WNW 22	W 22	WNW 26	WNW 26	WNW 22	WNW 22	WNW 25	WNW 28	NW 28	NW 28	NW 28	WNW 28	W 28	WSW 28	W 22	WSW 15	SW 19	WSW 19	SW 22	WSW 22	WSW 26	WSW 28	WSW 28	WNW 46	0700
11	WSW 26	WSW 22	WSW 22	WSW 19	WSW 19	WSW 19	W 15	N 19	N 28	N 28	N 28	N 28	NE 22	NE 19	NNE 9	NE 11	NE 9	ENE 9	NE 9	NE 15	ENE 4	C	C	C	N 46	1500
12	N 9	C	C	NW 9	NW 9	NW 9	NW 9	N 9	N 11	NNE 11	NE 13	N 13	NE 15	NE 11	N 13	NNE 15	NNE 15	N 15	NE 13	NE 9	NE 6	ENE 6	ESE 11	SE 15		
13	SE 9	S 1	ESE 9	ESE 6	ESE 9	SE 9	S 6	S 11	SE 15	SE 19	SE 22	SSE 24	SSE 26	SE 26	SSE 28	SSE 22	SSE 26	SSE 24	S 15	SE 11	ESE 9	SE 9	ESE 15	ESE 15	SSE 37	1600
14	ESE 15	ES 1	SE 13	SE 11	SE 11	ESE 11	ESE 19	SSE 15	N 6	NNW 4	N 4	N 15	NNE 9	NNE 9	N 15	N 11	N 15	NW 9	NW 6	NW 6	C	ESE 6	SW 9	SW 7		
15	[illegible] 9	S [illegible]	SW 11	SSW 13	SSW 11	SSW 11	SSW 11	SSW 15	SSW 15	SSW 26	SSW 19	SSW 22	SW 28	SW 28	SW 28	SW 22	SW 13	SW 24	WSW 22	W 13	WNW 9	NNE 9	NNW 9	NNE 15		
16	NE 11	C	C	C	C	ESE 7	ESE 7	SSE 15	S 9	SSE 13	SSE 22	SSE 19	S 19	S 22	S 22	S 19	S 22	S 28	S 28	S 22	SSE 15	S 22	S 28	S 28	S 22	2200
17	S 22	S 22	S 33	S 22	S 33	S 28	S 28	S 28	S 26	S 28	S 28	WSW 28	WSW 19	WNW 13	W 28	W 26	W 26	W 26	W 22	W 22	WSW 19	W 15	WSW 15	WSW 22	S 46	0200
18	WSW 22	WSW 19	WSW 19	WSW 19	WSW 19	WSW 19	WSW 15	WSW 26	WSW 28	W 26	W 28	W 28	WSW 28	WSW 28	WSW 28	WSW 26	WSW 26	WSW 22	WSW 15	WSW 15	W 9	NE 6	C	WSW 13	NW 46	1500
19	[illegible]	N 5	SW 9	C	WSW 9	C	C	SW 7	C	N 6	N 9	N 15	NNW 22	N 15	NNW 9	N 9	N 9	E 6	E 9	SSE 9	S 15	SE 9	S 6	SSE 9		
20	SSW [illegible]	SW 9	WSW [illegible]	W 9	WNW 9	C	C	S 6	C	SSE 7	SSE 13	S 15	SSE 7	S 15	N 15	N 15	NNW 15	N 22	NE 22	NE 19	NE 7	NE 13	NE 13	NE 15		
21	C	NE 6	NE 6	C	NNW 9	C	C	N 7	N 11	N 11	N 15	N 19	N 15	N 19	N 19	N 19	N 19	ENE 15	ENE 15	ENE 13	N 6	ENE 7	C	C		
22	C	C	C	C	C	C	C	C	S 13	S 15	SSE 9	C	SSE 15	SSE 15	S 15	SSE 15	ESE 15	S 15	ESE 15	ESE 15	ESE 15	ESE 11	ESE 11	ESE 9		
23	SE 15	SSE 11	SSE 11	SSE 13	SSE 11	SSE 15	S 19	S 11	SSE 9	SSE 15	SSE 9	S 22	SSE 19	SSE 15	S 19	S 22	S 22	S 22	S 26	S 22	S 22	S 22	S 22	S 22	S 44	1800
24	S 15	S 19	S 19	SSW 15	SW 22	WSW 26	WSW 19	WSW 22	WSW 19	WSW 19	SW 15	SSW 15	SW 19	S 22	S 22	SSW 22	WSW 22	WSW 19	WSW 19	WSW 15	WSW 15	S 11	S 11	SSW 19	WSW 37	1600
25	S 22	S 26	S 22	S 22	S 15	S 26	SSW 26	SSW 26	SW 26	SW 26	SW 37	SW 26	WSW 26	WSW 26	SW 28	WSW 26	W 26	W 26	W 22	W 19	W 11	WSW 15	SW 11	WSW 11	SW 56	1000
26	W 9	W 9	W 11	WSW 9	WSW 9	W 19	WSW 9	W 15	W 15	W 22	WNW 25	WNW 17	W 13	WNW 15	NW 15	NW 19	NNW 19	NNW 22	NNW 19	NW 11	WNW 9	W 9	WSW 7	WSW 6		
27	WSW 6	W 9	W 9	W 9	W 11	W 11	WNW 11	NW 15	NNW 19	N 19	N 13	C	S 9	WSW 13	SSW 19	SSW 19	SSW 19	S 15	SSE 9	S 9	SSE 9	SSE 15	SE 11	SSE 19		
28	S 19	S 19	S 19	S 23	SSE 26	SSE 28	SSE 28	SSE 26	SSE 26	SSE 26	SSE 26	S 22	S 19	S 22	S 22	S 19	WSW 13	SW 15	SW 11	W 7	WSW 7	W 4	SW 6	SW 4	S 48	1900
29	C	C	C	C	S 9	S 9	SSE 9	S 15	SSE 11	S 13	SSE 22	SSE 22	SSE 22	S 19	S 28	SSW 19	N 6	N 15	NW 9	NNW 11	SSE 9	W 6	WSW 6	SW 11		
30	[illegible] 13	WSW [illegible]	SW [illegible]	SW 9	SW 11	W 9	SSW 11	SSW 15	WSW 22	W 22	[illegible] 22	[illegible] 19	[illegible] 13	[illegible] 22	[illegible] 22	[illegible] 22	[illegible] 22	[illegible] 15	[illegible] 15	[illegible] 9	[illegible] 9	[illegible] 7	[illegible] 6	[illegible] 6		
31																										

On indique un vent d'ouest par la lettre 'W'.

*Indicates later occurrences of same speed
*Indique des données postérieures de la même vitesse