

RESEARCH REPORT



Oil-Fired Appliance Depressurization Spillage Testing



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**OIL-FIRED APPLIANCE
DEPRESSURIZATION SPILLAGE
TESTING**

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RESEARCH HIGHLIGHT

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Technical Series 07-109

Testing Oil-fired Appliance Depressurization Spillage

INTRODUCTION

It has been impossible to find oil-fired equipment designed to work in houses with negative pressures. House depressurization can cause combustion, which creates objectionable odours and may have health implications. This *Research Highlight* relates how one manufacturer of oil appliances investigated solutions for spillage and odours.

Spillage from combustion appliances in Canadian homes is a complex problem. The frequency and severity of combustion spillage is affected by the airtightness level of the house, the way the equipment is installed and the use of other air-exhausting equipment in the home. Other air-exhausting equipment can overpower the appliance venting system and cause combustion spillage.

Existing Canadian codes and standards have attempted to deal with combustion spillage by such strategies as requiring makeup air supplies for installations that may not have sufficient air leakage to support the proper operation of the combustion appliances.

Manufacturers have also developed appliances that are more spillage-resistant. However, there is no standard protocol to directly test and rate products for resistance to combustion spillage. Manufacturers have not had an accepted way to notify consumers, builders or other stakeholders of the rated spillage resistance of their appliances, or to indicate which of their products perform better under reduced pressure conditions that might cause spillage in other products.

The depressurization-spillage test was developed by Canada Mortgage and Housing Corporation, Natural Resources Canada and other stakeholders as a key instrument in addressing this gap.

The combustion-spillage test uses CO₂ produced in combustion as a tracer gas. The amount of CO₂ spilled into the test room for a particular level of depressurization is measured and totalled over the duration of the test. This is then compared with the amount of CO₂

produced by combustion during the test to determine the percentage of combustion spillage. *Combustion spillage* is defined as any products that are formed by combustion of a fuel that are released from the appliance or its venting system into the test room.

Kerr Heating Products of Parrsboro, N.S., partnered with CMHC and NRCan to develop its in-house capabilities for evaluating the spillage resistance of oil-fired appliances. During the project, Kerr installed, commissioned and used an in-house depressurization-spillage test facility.

The facility, the test procedure and calculations were similar to those that were used for natural gas appliances in an earlier CMHC project (see *References* at the end of this *Research Highlight*). This project is the first time that any Canadian HVAC (heating, venting and air conditioning) manufacturer has expanded its product development capabilities by building and using in-house depressurization-spillage testing tools. It was also the first time that the test had been used with appliances intended for vertical (chimney) venting. The Kerr team updated the calculations from the earlier gas-fired project to incorporate the correct fuel composition for oil-fired equipment. Kerr evaluated several design alternatives and instrumentation choices for the test room. The full project report explains the decisions and provides full details for the updated test procedure and its associated calculations. Performance measurements for some residential oil-fired combustion appliances are provided at different depressurization levels. Kerr provided a template to enable other appliance manufacturers to readily deploy their own in-house depressurization testing capabilities.

This research project focused on identifying challenges for a manufacturer implementing the spillage test. The manufacturer has to overcome these barriers and take the test from a laboratory setting (where it has already been proven to work) to its own product development environment.

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This project also produced test results on the combustion-spillage performance of some oil-fired heating products with a range of different vent configurations and components.

RESEARCH PROGRAM

The research program was conducted between December 2005 and August 2006 at Kerr's product development facility in Truro, N.S.

A second-hand environmental room was purchased and reassembled for this research program. A pressure blower with an adjustable inlet damper was installed to exhaust air from the room and control the test room pressure at the desired level.

Instrumentation was purchased and installed to measure the amount of air removed as well as the concentration of carbon dioxide (CO_2) in the air removed from the test room. The fuel consumption, CO_2 level in the area surrounding the test room, test room temperature and pressure and flue gas measurements in the appliance vent were also taken for each test.

A data acquisition system automatically logged test data and a Microsoft Excel template was developed to perform calculations for each test and account for changes in test-room temperature, barometric pressure and so on during each test and between tests.

For each test, the appliance with its vent system was first installed in the test room. The room was depressurized to the desired level and the appliance controls were adjusted so that the burner operated for five minutes.

The amount of CO_2 that was released or "spilled" into the test room was determined over seven minutes—the five that the burner operated and another two to include spillage of combustion gases from the venting system after the burner shut down. The amount of CO_2 spilled into the test room was divided by the amount of CO_2 produced by the burner to determine the percentage of combustion spillage for each test.

Full details of the procedure and calculations were included in spreadsheet templates. The templates are available on CD.

To simplify interpretation of test results, a tolerance level of allowable spillage was established for the testing. If the amount of spilled CO_2 exceeded two per cent of the CO_2 produced by combustion, the appliance was considered to have failed the depressurization spillage test.

The two per cent level corresponds with the project testing gas appliances and the "Gas Passageway Leakage Test" described in Section 21 of CSA B140.0-03, *Oil-Burning Equipment: General Requirements*. Note that B140.0 allows two per cent leakage for both the heat exchanger and the vent sections and that UL726, *Standard for Oil-Fired Boiler Assemblies*, allows four per cent spillage from the combustion chamber—vent section and eight per cent from the air intake section. The two per cent level for this research project is at least twice as stringent since all of the interfaces are not tested in the B140.0 or UL requirements. Further work based on health considerations may be required to establish an "acceptable" combustion spillage level for installed oil-fired equipment.

RESEARCH FINDINGS

Cost of new test equipment

Most appliance manufacturers will already have much of the equipment and skills needed to perform depressurization testing. Kerr required some additional equipment for this research project.

Kerr selected and purchased the new test equipment for this project based on performance, cost and durability considerations. The equipment needed to be accurate enough to ensure that the spillage was properly determined, be easy to operate and have the appropriate ruggedness and reliability for use in an industrial environment.

Table 1 gives the range and accuracy of the instruments selected.

Table 1 Measurement ranges and instrument accuracy specifications

Measured property	Range	Accuracy
CO_2	0–1,000 ppm	$\pm 1\%$ full scale
Flow	0–500 cfm	$\pm 0.5\%$
Pressure 1	0–200 Pa	$\pm 1\%$ reading
Pressure 2	0–2000 Pa	$\pm 1\%$ reading
Temperature	0–200°F	$\pm 2^\circ\text{F}$

Table 2 lists the equipment Kerr purchased for this project.

Table 2 Equipment list and purchase cost

Item	Purpose	Cost
1 test room	To allow depressurization testing	\$4,150
1 depressurization fan/motor	To depressurize test room and overcome pressure difference across flow element	\$444
1 laminar flow element	To measure flow from test room	\$1,800
2 CO ₂ meters	To measure CO ₂ in test room and adjacent room	\$5,000
1 calibration gas	To calibrate CO ₂ meters	\$270
1 digital manometer	To measure static pressure and pressure difference across the laminar flow element	*
1 digital manometer	To measure depressurization level in test room	*
1 combustion gas CO ₂ analyzer	To determine the flow through the burner and barometric for non-direct vent systems	*
1 programmable logic controller	To control test events (optional)	*
1 data acquisition system	To collect data	*
5 thermocouples	To measure temperatures	*
1 computer	To record test parameters and process data	*
1 digital camera	To record test set ups	*
1 scale	To determine weight of fuel used	*
Cost of new equipment		\$11,664

* Equipment already available to Kerr – no purchase required

Description of tested appliances

The project tested oil-fired furnaces and hot water boilers. Table 3 is a list of the appliances and their venting configuration. Configurations identified as “Direct Vent” did not use barometric dampers. The systems were tested for combustion spillage at different depressurization levels, nominally 5 Pa, 8 Pa, 20 Pa and 50 Pa.

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Table 3 Tested appliances and vent configurations

Product type	Venting configuration
Warm air furnace	Chimney (extended vent) with barometric damper
Warm air furnace	Chimney (extended vent) with no barometric damper
Warm air furnace	Chimney (short vent) with barometric damper
Warm air furnace	Chimney (short vent) with no barometric damper
Warm air furnace	Chimney (extended vent) with barometric damper
Warm air furnace	Chimney (extended vent) with barometric damper
Warm air furnace	Chimney (extended vent) with no barometric damper
Warm air furnace	Chimney (short vent) with barometric damper
Warm air furnace	Chimney (short vent) with no barometric damper
Warm air furnace	Flex vent connected to chimney, combustion air from room
Warm air furnace	Direct vent
Warm air furnace	Direct vent
Warm air furnace	Direct vent with quick disconnect 1
Warm air furnace	Direct vent with quick disconnect 2
Hot water boiler	Direct vent
Hot water boiler	Direct vent with quick disconnect 1
Hot water boiler	Direct vent with different burner flanges

Results

Figure 1 summarizes the results of the spillage tests. See also Table 4.

It is important to note that the main focus of this project was to refine, evaluate and demonstrate the test protocol with oil-fired appliances—not to develop the appliances. However, it is likely that the installation procedures for the later tests were improved from the earlier tests because of what had been learned during the project.

Different appliances and components were used to evaluate the spillage test with a variety of configurations. There was no attempt to undertake comprehensive comparative evaluations of the performance of an appliance operating with the different configurations identified in Table 4 and all configurations were not tested at all depressurization levels.

Except for some fairly simple modifications, no efforts were taken to improve the performance of any of the appliances during this project. This explains why the results show varying spillage for similar configurations.

Figure 1: Depressurization Level vs. Spillage (All Tested Configurations)

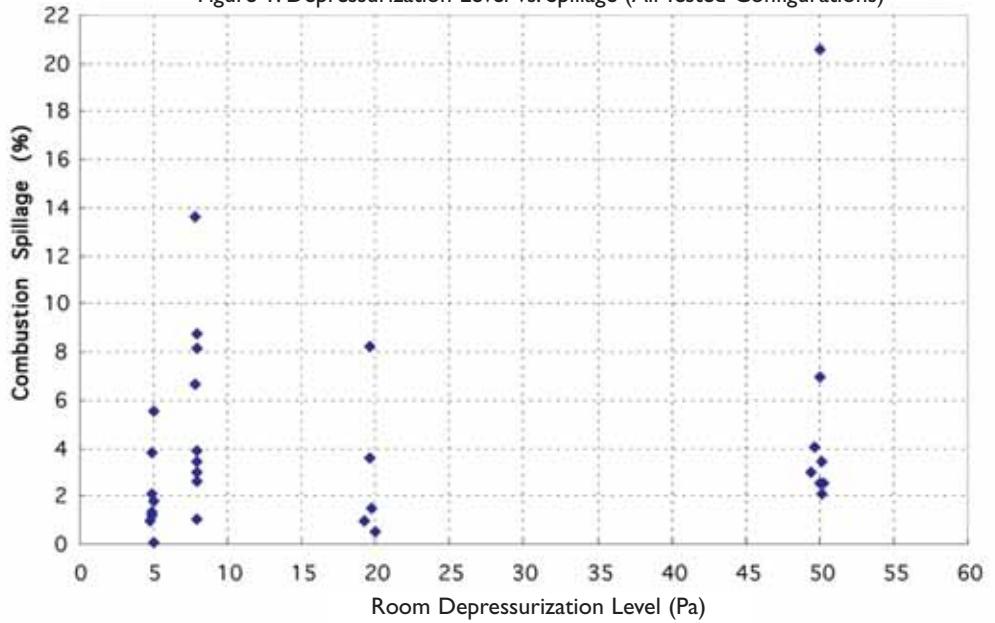


Figure 1 Results of spillage tests

Table 4 Spillage results with different types of venting systems

Type of venting system	Depressurization (Pa)	Amount of spillage (%)
Chimney with barometric	5	1–6
Chimney without barometric	5	1–7
Chimney with barometric	8	3–14
Chimney without barometric	8	1–7
Flex vent connected to chimney Combustion air from room, no barometric	8	1
Flex vent connected to chimney Combustion air from room, no barometric	20	8
Flex vent connected to chimney Combustion air from room, no barometric	50	21
Direct vent	50	1–7

CONCLUSIONS

Easy-to-use test—a useful tool for product development

A key conclusion from this project is that a low-cost test is now available that allows manufacturers of oil-fired appliances to directly determine the effects of depressurization on their equipment.

This test has proven very useful in evaluating different design alternatives for effectiveness when subjected to a depressurized environment. The spillage test can be easily and inexpensively implemented by other manufacturers.

Kerr has decided that this capability is an important tool for the development of future oil-fired systems. It has already incorporated the new tool in their other projects, including ones to evaluate different burner flange designs, quick-release vent couplings and a reversible breech, low-boy furnace.

Sensitivity and repeatability

The sensitivity of the test is such that subtle differences cited in the above examples could be determined. Repeatability is good and well within the requirements of a test of this type. The test is very quick to perform once the appliance is set up. Warm air furnaces require a brief cool-down between tests, which can be reduced by turning the exhaust fan to high speed.

Some systems can withstand significant depressurization

Figure 1 shows that there are systems that pass the two per cent spillage test, even when operated up to 50 Pa depressurization. While there was a wide range of spillage results for the tested configurations, the two per cent spillage limit is obtainable with good appliance and venting system design and good installation practices.

Effect of different venting systems

Chimney-vented appliances that used barometric dampers did not perform well above 5 Pa depressurization. This finding was expected, but it is important to note the appliance has little impact on the spillage since most occurs in the vent and through the barometric damper. Careful attention to sealing the smoke pipe helps. Traditional smoke pipe does not perform well in a depressurized environment unless the joints are sealed with aluminum tape.

A hybrid vent system taking combustion air from the room but venting into a sealed exhaust with no barometric damper offers much higher resistance to depressurization spillage than a conventional chimney vent. This venting approach appears to offer some promise for future products.

Current oil-fired direct vent technologies, such as sealed-combustion direct venting, can meet a spillage requirement of two per cent or less at 50 Pa depressurization when properly designed and installed.

However, direct venting has some problems related to venting out the sidewall. There appears to be good potential for developing and demonstrating an upgraded type of combustion venting system that would draw its combustion air from outside the house envelope while venting vertically, without using a barometric damper. This approach would have the advantages of current direct-vent systems without the problems related to sidewall venting.

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Effect of different burner designs

Although only four different burners were tested there are clearly differences among burner designs with respect to depressurization spillage. The approach to sealing the burner flange to the boiler or furnace also had an impact on spillage. This information can be used by burner manufacturers to improve their depressurization performance. Two major oil burner manufacturers have already expressed interest in this work and it is anticipated that burner depressurization performance will be improved in the future.

Value to manufacturers

Kerr originally considered building a test facility that could be dismantled when not in use. Kerr has found the facility to be extremely useful during the product development cycle, and now uses it regularly. Knowledge from depressurization testing has already been used to upgrade installation practices and manuals.

Value to industry

Given that the incidence of depressurizing homes is increasing and recognizing that spillage of combustion products from oil-fired appliances creates both soot and odour, there is a significant opportunity for stakeholders within the industry to develop their own testing capability and to use that capability to reduce depressurization-related performance issues.

REFERENCES

Laboratory depressurization test for residential gas appliances, CMHC Research Highlight—Technical Series 05-111, October 2005.

Depressurization spillage test final report, prepared by Peter Edwards Co. for CMHC and NRCan, July 2005.

Laboratory evaluation to assess a proposed test method to determine transient combustion spillage, prepared by Bodycote Materials Testing Canada Inc. for NRCan, July 2005.

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Funding Partner: Natural Resources Canada (NRCan)

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LE POINT EN RECHERCHE

Mars 2007

Série technique 07-109

Essais d'appareils au mazout rejetant des émanations sous l'effet de la dépressurisation

INTRODUCTION

Il s'est avéré impossible de trouver des équipements fonctionnant au mazout conçus pour fonctionner dans une maison sous pression négative. La dépressurisation dans une maison peut entraîner le refoulement des gaz de combustion, ce qui engendre des odeurs désagréables et peut avoir des répercussions sur la santé. Ce *Point en recherche* décrit comment un fabricant d'appareils au mazout s'y est pris pour trouver des solutions aux problèmes de refoulement et d'odeurs.

Les émanations provenant d'appareils à combustion dans les maisons au Canada constituent un problème complexe. La fréquence et la sévérité des refoulements de gaz de combustion est tributaire du niveau d'étanchéité à l'air de la maison, de la façon dont l'équipement est installé et de l'utilisation d'autres ventilateurs d'extraction. Ces autres ventilateurs d'extraction peuvent surclasser l'évent de l'appareil au mazout et occasionner un refoulement de gaz de combustion.

Les codes et normes en vigueur à l'heure actuelle au Canada ont tenté de régler le problème de refoulement au moyen de stratégies comme le fait d'exiger une alimentation d'air comburant dans les maisons qui ne présentent peut-être pas suffisamment de fuites d'air pour alimenter convenablement en air comburant les appareils à combustion.

Les fabricants ont également mis au point des appareils qui sont moins sujets aux refoulements. Toutefois, aucun protocole ne permet de mettre à l'essai et de coter directement des produits quant à leur résistance au refoulement des gaz de combustion. Ils ne disposent donc pas de méthode normalisée pour communiquer aux consommateurs, constructeurs et intervenants la cote de résistance au refoulement de leurs appareils, ou d'indiquer quel de leurs produits affiche une meilleure performance sous des conditions de pression réduite qui pourraient provoquer un refoulement de gaz dans d'autres produits.

L'essai de dépressurisation-refoulement a été élaboré par la Société canadienne d'hypothèques et de logement (SCHL), Ressources Naturelles Canada (RNCan) et d'autres intervenants à titre d'outil privilégié pour pallier ce manque.

L'essai de refoulement des gaz utilise le CO₂ produit par la combustion comme gaz de dépistage. La quantité de CO₂ qui refoule dans la chambre d'essai à un niveau particulier de dépressurisation est mesurée et additionnée pour la durée de l'essai. Cette quantité est ensuite comparée à la quantité de CO₂ produite par la combustion durant l'essai afin de déterminer le pourcentage de gaz de combustion refoulés. Le *refoulement des gaz de combustion* se définit comme tout produit découlant de la combustion d'un combustible dégagé par un appareil ou son événement, dans la chambre d'essai.

Kerr Heating Products de Parrsboro, en Nouvelle-Écosse, en partenariat avec la SCHL et RNCan, a voulu se donner les moyens d'évaluer la résistance aux refoulements des appareils à combustion au mazout. Au cours des travaux, Kerr Heating Products a installé et mis en service une installation d'essai de dépressurisation-refoulement.

Les installations d'essai, la méthode d'essai et les calculs étaient semblables à ceux employés pour la mise à l'essai d'appareils à gaz dans une étude antérieure de la SCHL (voir les *Références* à la fin du présent *Point en recherche*). C'était la première fois qu'un fabricant canadien d'équipements de CVC (chauffage, ventilation et climatisation) élargissait ses moyens en matière de développement de produits en construisant et en utilisant des outils maison d'essai de dépressurisation-refoulements. C'était également la première fois que l'essai visait des appareils dotés d'éléments d'évents verticaux (cheminées). L'équipe de Kerr a mis à jour les calculs tirés des travaux antérieurs sur les appareils à gaz pour leur incorporer la bonne composition du combustible pour l'équipement au mazout. Kerr a évalué plusieurs concepts de recharge et choix d'instrumentation pour la chambre d'essai. Le rapport complet décrit en détail les décisions prises et donne de plus amples détails sur la méthode d'essai mis à jour, de même que sur les calculs connexes. Les mesures de performance pour certains appareils au mazout résidentiels sont données pour différents niveaux de dépressurisation.

Kerr a mis au point un modèle informatisé qui permettra à d'autres fabricants d'appareils au mazout de se doter aisément de leur propre installation maison d'essai de dépressurisation.

La recherche dont il est question ici était axée sur la découverte des difficultés auxquelles fera face un fabricant qui met en œuvre l'essai de refoulement. Ce dernier doit surmonter ces difficultés et transposer l'essai depuis le laboratoire (où l'essai s'est avéré) à son propre milieu de développement de produits.

Les travaux ont également abouti sur des résultats d'essais portant sur la performance de certains appareils au mazout dotés de différents composants et agencements d'évent, quant à leur résistance au refoulement des gaz de combustion.

PROGRAMME DE RECHERCHE

Le programme a été mené entre décembre 2005 et août 2006, dans les installations de développement de produits de Kerr, à Truro, en Nouvelle-Écosse.

Kerr s'est procuré une chambre atmosphérique d'occasion, puis elle a été assemblée de nouveau pour les besoins des présents travaux de recherche. Un puissant ventilateur d'extraction doté d'un volet d'admission réglable a été posé pour évacuer l'air de la chambre et maintenir la pression dans la chambre au niveau souhaité.

Le système d'instruments a été acheté puis posé afin de mesurer la quantité d'air évacuée, de même que la concentration de dioxyde de carbone (CO_2) dans l'air retiré de la chambre d'essai. Au cours de chaque essai, on a enregistré la consommation de combustible, la teneur en CO_2 dans les zones entourant la chambre d'essai, la température et la pression dans la chambre d'essai, ainsi que des mesures des gaz de combustion dans l'évent de l'appareil.

Un système d'acquisition de données a enregistré automatiquement les données et un modèle en format Excel de Microsoft a été élaboré pour exécuter les calculs à chaque essai, et tenir compte des changements dans la chambre d'essai, comme la température, la pression barométrique, etc. pour chaque essai, de même qu'entre les essais.

Pour chacun expérience, l'appareil et son événement ont d'abord été installés dans la chambre d'essai. La chambre a été dépressurisée jusqu'au niveau souhaité et les commandes de l'appareil ont été réglées de manière à ce que le brûleur fonctionne pour cinq minutes.

La quantité de CO_2 émise ou « refoulée » dans la chambre d'essai a été enregistrée sur une période de sept minutes : les cinq minutes pendant lesquelles le brûleur fonctionnait, et les deux minutes additionnelles pour inclure les émanations provenant du système d'évent, après l'arrêt du brûleur. La quantité de CO_2 refoulée dans la chambre d'essai a été divisée par la quantité de CO_2 produite par le brûleur pour déterminer la proportion de gaz refoulé au cours de chaque essai.

Tous les détails relatifs à la méthode et aux calculs ont été consignés dans les modèles sur chiffrer disponibles sur CD-ROM.

Pour simplifier l'interprétation des résultats, un niveau de tolérance de refoulement admissible a été établi pour les essais. Si la quantité de CO_2 excédait 2 % du CO_2 produit par la combustion, l'appareil avait pour ainsi dire échoué l'essai de dépressurisation.

La limite de 2 % correspond à celle de l'étude sur les appareils à gaz et à l'essai d'« étanchéité du parcours des gaz » décrit dans section 21 de la norme CSA B140.0-F03, Appareils de combustion au mazout : Exigences générales. Il est à noter que la norme B140.0-F03 autorise une fuite de 2 %, à la fois pour l'échangeur de chaleur et les sections d'évent, et que la norme UL726, Standard for Oil-Fired Boiler Assemblies, permet un refoulement de 4 % depuis la chambre de combustion et la section d'évent, et de 8 % depuis la section d'admission d'air. La limite de 2 % établie pour la recherche dont il est question ici est au moins deux fois plus sévère, puisque ce ne sont pas toutes les interfaces qui sont mises à l'essai aux termes de la norme B140.0 et les exigences des laboratoires UL. Des travaux plus poussés fondés sur des exigences liées à la santé seront peut-être nécessaires afin d'établir un niveau « acceptable » d'émanations rejetées par les équipements au mazout en service.

RÉSULTATS

Coût du nouvel équipement d'essai

La plupart des fabricants d'appareils de combustion au mazout possèdent déjà nombre des pièces d'équipement et les compétences requises pour effectuer des essais de dépressurisation. Kerr avait besoin d'équipements de mesure additionnels pour réaliser l'étude.

Kerr a choisi d'acheter le nouvel équipement d'essai en se fondant sur des considérations de performance, de coût et de durabilité. L'équipement devait être suffisamment précis pour garantir que les refoulements soient mesurés convenablement, être facile à utiliser et posséder des qualités de robustesse et de fiabilité convenant à un milieu industriel.

Le tableau 1 donne la fourchette d'utilisation et la précision des instruments acquis.

Le tableau 2 présente la liste des équipements achetés par Kerr pour les essais.

Tableau 1 Fourchettes de mesures et précision des instruments

Propriété à mesurer	Fourchette	Précision
CO ₂	0 à 1 000 ppm	±1 %, pleine échelle
Débit	0 à 500 pi ³ /min	±0,5 %
Pression 1	0 à 200 Pa	±1 %, lecture
Pression 2	0 à 2000 Pa	±1 %, lecture
Température	0 à 200 °F	±2 °F

Tableau 2 Liste des équipements et leur coût d'acquisition

Élément	Utilisation	Coût (\$)
1 chambre d'essai	Permet de réaliser les essais de dépressurisation	4 150
1 ventilateur de dépressurisation	Dépressuriser la chambre d'essai et surmonter la différence de pression de part et d'autre de l'élément	444
1 élément à écoulement laminaire	Mesurer l'écoulement depuis la chambre d'essai	1 800
2 analyseurs de CO ₂	Mesurer la teneur en CO ₂ dans la chambre d'essai et la pièce adjacente	5 000
1 gaz de calibration	Calibrer les analyseurs de CO ₂	270
1 manomètre numérique	Mesurer la pression statique et la différence de pression de part et d'autre de l'élément à écoulement laminaire	*
1 manomètre numérique	Mesurer le niveau de dépressurisation dans la chambre d'essai	*
1 analyseur de CO ₂ pour les gaz de combustion	Déterminer l'écoulement à travers le brûleur et le volet barométrique dans le cas des installations qui ne sont pas à ventouse	*
1 commande logique programmable	Contrôler les événements d'essai (optionnelle)	*
1 système d'acquisition de données	Collecte de données	*
5 thermocouples	Mesurer les températures	*
1 ordinateur	Enregistrer les paramètres des essais et traiter les données	*
1 caméra numérique	Consigner sur photos les installations d'essai	*
1 balance	Déterminer le poids du combustible utilisé	*
Coût total du nouvel équipement		11 664

* Équipements déjà disponibles chez Kerr – aucun achat requis.

Description des appareils mis à l'essai

Des générateurs de chaleur et des chaudières au mazout ont été mis l'essai. La liste des appareils et leur mode de ventilation figurent au tableau 3. Le mode de ventilation indiqué comme « événement à évacuation directe » est dépourvu de volet barométrique. Les essais ont été menés sur les installations sous différents niveaux de dépressurisation, soit 5, 8, 20 et 50 Pa.

Tableau 3 Appareils mis à l'essai et modèles d'événement

Type de produit	Mode de ventilation
Appareil à air pulsé	Cheminée (évent long) avec volet barométrique
Appareil à air pulsé	Cheminée (évent long) sans volet barométrique
Appareil à air pulsé	Cheminée (évent court) avec volet barométrique
Appareil à air pulsé	Cheminée (évent court) sans volet barométrique
Appareil à air pulsé	Cheminée (évent long) avec volet barométrique
Appareil à air pulsé	Cheminée (évent long) avec volet barométrique
Appareil à air pulsé	Cheminée (évent long) avec volet barométrique
Appareil à air pulsé	Cheminée (évent court) avec volet barométrique
Appareil à air pulsé	Cheminée (évent court) sans volet barométrique
Appareil à air pulsé	Événement flexible raccordé à la cheminée, air comburant provenant de la pièce
Appareil à air pulsé	Événement à évacuation directe
Appareil à air pulsé	Événement à évacuation directe
Appareil à air pulsé	Événement à évacuation directe, doté d'un raccord rapide 1
Appareil à air pulsé	Événement à évacuation directe, doté d'un raccord rapide 2
Chaudière à eau chaude	Événement à évacuation directe
Chaudière à eau chaude	Événement à évacuation directe, doté d'un raccord rapide 1
Chaudière à eau chaude	Événement à évacuation directe, muni des plaques brûleuses différentes

Résultats

La figure 1 présente un résumé de résultats des essais de dépressurisation-refoulement. Voir aussi le tableau 4.

Tableau 4 Résultat de refoulement des appareils munis de différents types d'événements

Type de système de ventilation	Dépressurisation (Pa)	Montant de refoulement (%)
Cheminée avec volet barométrique	5	1 à 6
Cheminée sans volet barométrique	5	1 à 7
Cheminée avec volet barométrique	8	3 à 14
Cheminée sans volet barométrique	8	1 à 7
Événement flexible raccordé à la cheminée Air comburant de la pièce, sans volet barométrique	8	1
Événement flexible raccordé à la cheminée Air comburant de la pièce, sans volet barométrique	20	8
Événement flexible raccordé à la cheminée Air comburant de la pièce, sans volet barométrique	50	21
Événement direct	50	1 à 7

Il importe de noter que cette étude avait pour objectif principal d'améliorer, d'évaluer et de faire connaître le protocole d'essai sur les appareils au mazout, et non pas de les mettre au point. Il est probable, toutefois, que les leçons retenues à la suite des premiers essais aient permis d'améliorer le processus d'installation des derniers essais.

Differents appareils et composants ont permis de mener des essais selon une variété d'agencements. On n'a pas cherché à entreprendre des évaluations comparatives globales de la performance d'un appareil fonctionnant sous les différents agencements qui figurent au tableau 4, et ce ne sont pas tous les agencements qui ont été mis à l'essai à tous les niveaux de dépressurisation.

Sauf pour quelques modifications relativement simples, aucun effort visant à améliorer la performance d'un appareil n'a été déployé au cours des travaux. C'est pourquoi les résultats donnent des niveaux de refoulement variables pour des agencements semblables.

Figure 1 : Niveaux de dépressurisation contre les refoulements (tous les appareils mis à l'essai)

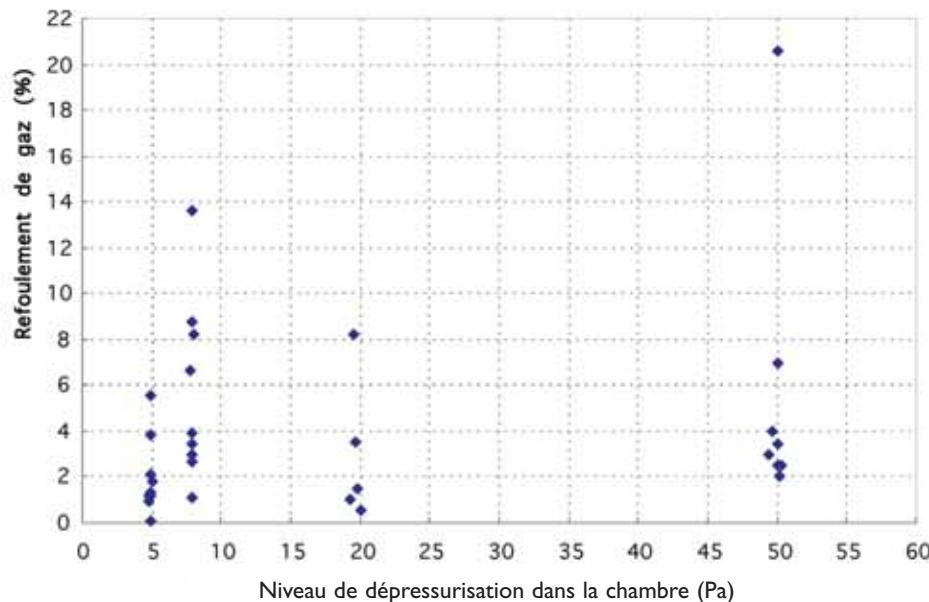


Figure 1 Résultats des essais de refoulement

CONCLUSIONS

Essai simple et utile pour le développement de produits

Voici ce qu'il faut retenir de ces travaux. Un essai à faible coût est maintenant disponible qui permet aux fabricants d'appareils au mazout de déterminer directement l'incidence de la dépressurisation sur leur équipement.

Cet essai s'est avéré très utile pour l'évaluation de l'efficacité des différents concepts sous l'effet de la dépressurisation. L'essai de dépressurisation-refoulement peut être mis en œuvre par d'autres fabricants assez aisément et à faible coût.

Kerr a décidé que ce genre d'installation constitue un outil important pour le développement d'appareils au mazout. Il a déjà intégré le nouvel outil à d'autres projets, dont celui visant à évaluer différents modèles de plaque brûleur, les raccords rapides pour événements, et un générateur d'air chaud à caissons juxtaposés à culotte réversible.

Sensibilité et reproductibilité

La sensibilité de l'essai est telle que de légères différences, comme indiqué ci-dessus, pouvaient être décelées. La reproductibilité est convenable et bien dans les limites des exigences pour un essai de ce genre. L'essai est aisément à mener une fois que l'appareil est mis en place. Les générateurs d'air chaud exigent une brève période de refroidissement entre les essais, laquelle peut être réduite au minimum si l'on fait fonctionner le ventilateur de dépressurisation à grande vitesse.

Certaines installations peuvent résister à une dépressurisation considérable

La figure 1 indique que certaines installations réussissent avec succès l'essai de refoulement à 2 %, même sous une dépressurisation de 50 Pa. Bien que les résultats varient considérablement pour les configurations mises à l'essai, la limite de refoulement à 2 % peut être satisfait si il s'agit d'un équipement et d'un concept de ventilation de qualité, et si on a mis en œuvre de bonnes pratiques d'installation.

Incidence de différents systèmes d'évent

Les appareils ventilés par une cheminée et qui sont dotés d'un volet barométrique ont affiché une piètre performance sous l'effet d'une dépressurisation de plus de 5 Pa. Ce résultat était certes attendu, mais il importe de noter que l'appareil en soi avait peu d'incidence sur le refoulement, puisque la plupart du temps, il se produisait par l'évent ou par le volet barométrique. Il convient donc de porter une attention particulière à l'étanchéité du tuyau à fumée. Les tuyaux à fumée classiques ne donnent pas une bonne performance sous l'effet de la dépressurisation, à moins que les joints soient scellés à l'aide de ruban d'aluminium.

Un système de ventilation hybride qui tire l'air combustible de la pièce, mais qui évacue les gaz dans un conduit d'évacuation étanche dépourvu de volet barométrique offre une résistance beaucoup plus grande aux refoulements occasionnés par la dépressurisation qu'un évent de cheminée classique. Ce modèle d'évent semble prometteur pour l'avenir.

Les appareils au mazout à ventouse de modèle courant, comme ceux à technologie à chambre de combustion scellée et à événement à évacuation directe, sont en mesure de satisfaire la limite de 2% de refoulement ou moins, sous l'effet d'une dépressurisation de 50 PA, lorsqu'ils sont convenablement conçus et installés.

Les événements à évacuation directe, toutefois, sont sujets à certains problèmes, lorsqu'il s'agit de ventouses murales. L'occasion semble bonne pour élaborer et faire connaître un système novateur d'évacuation des gaz de combustion qui tirerait l'air comburant de l'extérieur de l'enveloppe du bâtiment, tout en rejetant les gaz de combustion verticalement, sans faire usage d'un volet barométrique. Une telle méthode comporterait les avantages des systèmes à évacuation directe actuels, sans être touchée par les problèmes liés aux ventouses murales.

Incidence de différents modèles de brûleurs

Bien que seulement quatre différents brûleurs aient été mis à l'essai, il est évident que ceux-ci affichent des différences quant à leur efficacité à résister au refoulement de gaz sous l'effet d'une dépressurisation. Le concept qui consiste à sceller la plaque brûleur à la chaudière ou au générateur à air pulsé avait également des répercussions sur le refoulement. Les fabricants peuvent tirer avantage de cette information pour améliorer la performance de leurs appareils sous l'effet de la dépressurisation. Deux importants fabricants de brûleurs ont montré un intérêt pour les travaux, et il est prévu que la performance des brûleurs en dépressurisation sera améliorée dans le futur.

Conséquences pour les fabricants

À l'origine, Kerr avait l'intention de construire une installation d'essai démontable, lorsqu'elle est inutilisée. Puisque l'installation s'est avérée très utile durant le cycle de développement des produits, Kerr l'utilise régulièrement. Les connaissances acquises par suite des essais de dépressurisation ont déjà permis d'améliorer les manuels et les pratiques d'installation.

Conséquences pour l'industrie

Compte tenu de l'incidence accrue des situations de dépressurisation dans les maisons, et du fait que le refoulement de gaz de combustion provenant d'appareils au mazout engendre à la fois des odeurs et des dépôts de suie, les intervenants de l'industrie gagneraient à mettre au point leurs propres installations d'essai et à en profiter pour réduire l'occurrence des problèmes liés à la dépressurisation.

Directeur de projet à la SCHL : Don Fugler

Consultants pour le projet de recherche : Kerr Heating Products, Peter Edwards Co.

Partenaire en financement : Ressources Naturelles Canada (RNCAN)

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RÉFÉRENCES

Essais de dépressurisation en laboratoire visant les appareils à gaz résidentiels,
Le point en recherche SCHL — Série technique 05-111, octobre 2005.

Essais de dépressurisation – rapport final, par Peter Edwards Co., pour la SCHL et RNCAN, juillet 2005.

Laboratory evaluation to assess a proposed test method to determine transient combustion spillage, par Bodycote Materials Testing Canada Inc., pour RNCAN, juillet 2005.

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Forward

Kerr Heating Products (Kerr) is a leading manufacturer of oil-fired heating appliances. More information on Kerr and its products can be obtained at www.kerrheating.com.

Over the past several years Kerr recognized several developing trends that could impact the operation of its heating appliances in so far as these trends might lead to increased depressurization in homes. They included a movement towards tighter home construction, the use of higher powered exhaust equipment, and more people living in space adjacent to heating equipment. All of these trends could lead to increased likelihood of odour and spillage issues related to depressurization. Depressurization is a negative air pressure differential in a dwelling unit relative to atmospheric pressure. Given these trends, Kerr wanted to better understand the potential for spillage occurring in different product configurations and be better able to consider depressurization and spillage during product design.

Through the project discussed in this report, Kerr has become the first manufacturer in North America to develop the capability to test oil-fired heating equipment using this protocol, to evaluate a sample of oil-fired heating equipment and related venting and to use the related capability and know-how during the development of new products. The Government of Canada developed a similar depressurization testing protocol for natural gas-fired heating equipment.

This report has been developed to enable other heating equipment manufacturers to evaluate their products using the protocol. It is expected that with greater uptake of this test within the oil industry, manufacturers can work with their suppliers to enhance the depressurization resistance of component parts and subassemblies, and make oil-fired products with improved spillage resistance available to builders and consumers.

Acknowledgements

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1.0 Introduction & Background

Over the past several years Kerr noted anecdotal complaints of odours arising from spillage of oil-fired appliances appeared to be increasing. People are living closer to their appliances, are more environmentally aware and less tolerant of combustion spillage than in the past. Most of these problems related to combustion spillage occur when the appliance operates in an environment with some level of depressurization. Depressurization levels are increasing because houses are becoming tighter and there are more exhaust devices (such as, indoor grills, range hoods, clothes dryers and central vacuum systems) that exhaust air from the house and cause depressurization.

Kerr Heating Products (Kerr) saw standardized depressurization testing as a new research and development tool that could offer the company, and the rest of the oil heating industry, a way to significantly reduce these odour problems and to develop improvements to products and systems. If oil-fired appliances could be rated for their depressurization resistance, they would be viewed more favourably by homebuilders as the related risks of complaints and make-up air systems requirements would both be reduced. Currently homebuilders and appliance installers have to ensure they provide adequate combustion and make up air to appliances. This can be expensive and there is no standard way of meeting the requirements. Systems rated for depressurization can substantially reduce homebuilder costs and increase heating system reliability. Good performance under depressurized conditions could improve public perception of oil heat and make the industry more competitive. Thus Kerr encourages other manufacturers to use the same protocol as a product development tool so that odour issues can be minimized industry wide.

Kerr was aware of a new combustion depressurization spillage test and its use by a testing laboratory to evaluate the performance of gas appliances. The test developed in this project is based on the test for gas-fired appliances described in Development and Evaluation of a new Depressurization Spillage test for Residential Gas-Fired Combustion Appliances, Final Report, Peter Edwards Co., July 2005. Kerr was interested in developing its own in-house capabilities to evaluate oil-fired appliances. A project plan was developed aimed at achieving the following goals:

- to become the first appliance manufacturer to utilize this test protocol at their own facilities;
- to extend the use of the protocol to oil applications; and,
- to develop a template so that other manufacturers can readily develop their own in-house testing capabilities.

2.0 Depressurization Testing

2.1 Methodology

The main products of combustion of hydrocarbons are water (H_2O) and carbon dioxide (CO_2). The combustion spillage test uses the CO_2 produced by the combustion process as a tracer gas. The amount of spilled CO_2 for a particular level of depressurization is measured and totalled over a predetermined period of time. This is then compared with the stoichiometric amount of CO_2 that was produced by the combustion during the test. This determines the percent of combustion spillage. “Combustion Spillage” is defined as: *Any products that are formed by combustion of a fuel that are released from the appliance or its venting system into the test room.* It is assumed that the percentage spillage of CO_2 characterizes the spillage of other combustion products.

In order to perform the depressurization spillage test a “tight” room capable of being maintained at the desired depressurized level is required. A blower with adjustable flow rate is required to depressurize the room to the selected level and maintain the room pressure during the seven minute test with and without an operating appliance. Appropriate instrumentation is required to measure the room CO_2 , adjacent room CO_2 , exhaust flow, temperatures and pressure differentials. A data acquisition system is used to log the data and an Excel template is used to perform the calculations for each test.

The details of the calculations are contained in the spreadsheet files included in the available compact disc (CD) but the basic principle is outlined below:

$$\text{Spillage} = (\Delta CO_2(\text{test room}) - \Delta CO_2(\text{adjacent room})) * (\text{Exhaust Fan Flow} + \text{Appliance Exhaust Products Flow}) * (\text{Scaling Factor})$$

To simplify the interpretation of test results, a tolerance level of allowable spillage had to be established for the testing. If the amount of spilled CO_2 exceeds 2% of the stoichiometric CO_2 , the appliance is considered to have failed the depressurization spillage test. This 2% level was selected to correspond with the “Gas Passageway Leakage Test” described in Section 21 of CSA B140.0-03, Oil-Burning Equipment: General Requirements. Note that B140.0 allows 2% leakage for both the heat exchanger and the vent sections and the UL726, Standard for Oil-Fired Boiler Assemblies, allows 4% spillage from the combustion chamber – vent section (and 8% from the air intake section). Therefore the 2% level for this test is at least twice as stringent since all of the interfaces are not tested in the B140.0 or UL requirements.

The 2% tolerance level appears to be a reasonable value for spillage testing. Further work may be required to establish an “acceptable” spillage level for installed oil-fired combustion equipment based on health considerations.

The methodology is fully defined in the spreadsheet in the available CD.

2.2 Test Equipment

Most appliance manufacturers will have some of the equipment required to perform depressurization testing. A detailed description of the equipment is included in the appendices.

The test equipment was selected based on performance and cost. It had to have the accuracy to ensure that the spillage was properly determined. The test equipment also had to be easy to operate and have the appropriate ruggedness and reliability when subjected to an industrial environment.

The range and accuracy of the instruments selected for the measured parameters are given in the table below:

Measured Property	Range	Accuracy
CO ₂	0 - 1000 ppm	±1% Full Scale
Flow	0 - 500 cfm	±0.5%
Pressure 1	0 - 200 Pa	±1% Reading
Pressure 2	0 - 2000 Pa	±1% Reading
Temperature	0 - 200 °F	±2 °F

An equipment list is given below:

Equipment List

Item	Purpose	Quantity	Total Cost
Test Room	To allow depressurization testing	1	\$4,150
Depressurization Fan/Motor	To depressurize test room and overcome pressure difference across flow element	1	\$444
Laminar Flow Element	To measure flow from test room	1	\$1,800
CO ₂ Meter	To measure CO ₂ in test room and adjacent room	2	\$5,000
Calibration Gas	To calibrate CO ₂ meter	1	\$270
Digital Manometer	To measure static pressure and pressure difference across the laminar flow element	1	*
Digital Manometer	To measure depressurization level in test room	1	*
Combustion Gas Analyzer	To determine the flow through the burner and barometric for non-direct vent systems	1	*
Programmable Logic Controller	To control test events (optional)	1	*
Data Acquisition System	To collect data	1	*
Thermocouples	To measure temperatures	5	*
Computer	To record test parameters and process data	1	*
Digital Camera	To record test set ups	1	*
Scale	To determine weight of fuel used	1	*
Total Money Spent On New Equipment			\$11,664

* Equipment already owned by Kerr

2.3 Test Procedure

The detailed test procedure used for the testing conducted during this project is given in the appendices. This procedure may need to be modified slightly by each manufacturer depending on their equipment, room size and flow calibration factors. The test procedure can be adapted for either manual or programmable logic controller operation.

2.4 Test Appliances

The appliances tested in this project were all manufactured by Kerr Heating Products. Warm air furnaces and hot water boilers were tested. A list of appliances and venting configurations is given below. Configurations identified as "Direct Vent" did not use barometric dampers.

TEST APPLIANCES

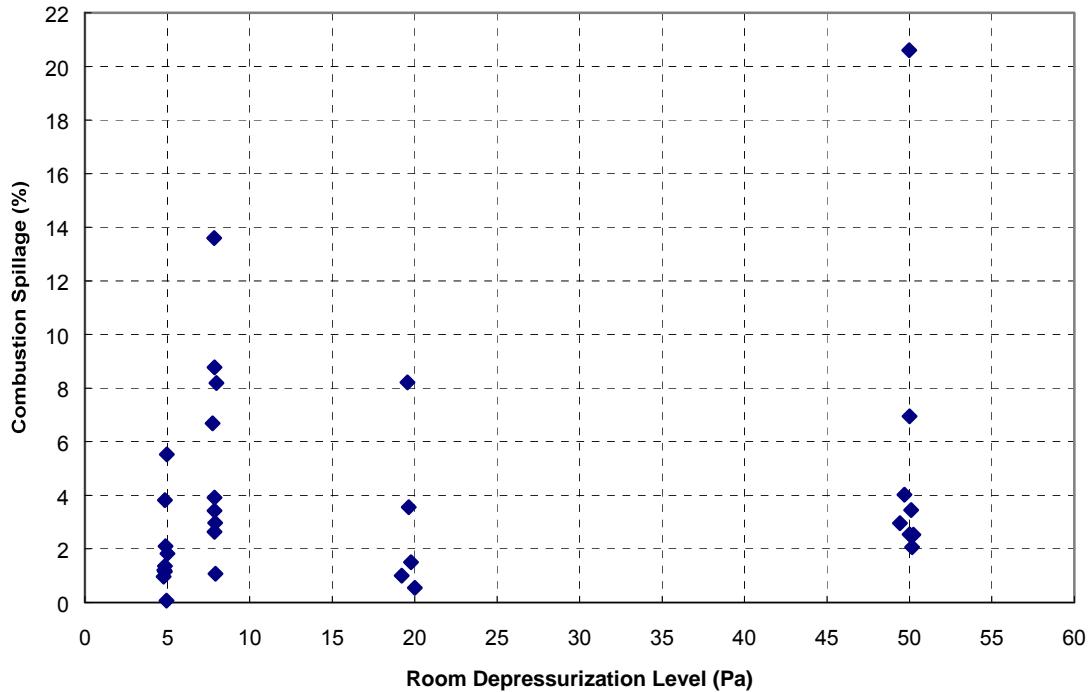
Type	Model	Venting
Warm Air Furnace	K6 Summit	Chimney (Extended Vent) With Barometric Damper
Warm Air Furnace	K6 Summit	Chimney (Extended Vent) With No Barometric Damper
Warm Air Furnace	K6 Summit	Chimney (Short Vent) With Barometric Damper
Warm Air Furnace	K6 Summit	Chimney (Short Vent) With No Barometric Damper
Warm Air Furnace	KM Eclipse	Chimney (Extended Vent) With Barometric Damper
Warm Air Furnace	KM Eclipse	Chimney (Extended Vent) With Barometric Damper
Warm Air Furnace	KM Eclipse	Chimney (Extended Vent) With No Barometric Damper
Warm Air Furnace	KM Eclipse	Chimney (Short Vent) With Barometric Damper
Warm Air Furnace	KM Eclipse	Chimney (Short Vent) With No Barometric Damper
Warm Air Furnace	KM Eclipse	Flex Vent Connected To Chimney, Combustion Air From Room
Warm Air Furnace	K4C MultiMax	Standard Direct Vent
Warm Air Furnace	KM Eclipse	Standard Direct Vent
Warm Air Furnace	KM Eclipse	Direct Vent With Quick Disconnect 1
Warm Air Furnace	KM Eclipse	Direct Vent With Quick Disconnect 2
Hot Water Boiler	Comet 95	Standard Direct Vent
Hot Water Boiler	Comet 95	Direct Vent With Quick Disconnect 1
Hot Water Boiler	Comet 95	Standard Direct Vent With Different Burner Flanges

2.5 Test Results

Details of all of the tests are included in the available compact disc. Full versions of the Excel spreadsheets are also included so that other manufacturers can use them as templates for their testing.

Figure 1 summarizes the results of all of the spillage tests.

Figure 1: Depressurization Level vs. Spillage (All Tested Configurations)



The various configurations and their spillage results are given in the table below.

Equipment Description	Depressurization (Pa)	Spillage (%)
Chimney with Barometric	5	1 - 6
Chimney without Barometric	5	1 - 7
Chimney with Barometric	8	3 - 14
Chimney without Barometric	8	1 - 7
Flex Vent Connected to Chimney Combustion Air from Room, No Barometric	8	1
Flex Vent Connected to Chimney Combustion Air from Room, No Barometric	20	8
Flex Vent Connected to Chimney Combustion Air from Room, No Barometric	50	21
Direct Vent	50	1 - 7

It is important to point out that the main focus of this project was to develop, evaluate and demonstrate the test protocol with oil-fired appliances and not to develop the appliances. However, it is likely that the installation procedures used with the later tests were improved from the earlier tests because of what had been learned during the project.

Different appliances and components were used to evaluate the spillage test with a variety of configurations. There was no attempt to undertake comprehensive comparative evaluations of the performance of an appliance operating with the different configurations identified in the above table. Except for some fairly simple modifications, no effort was taken to improve the performance of any of the appliances during this project. This explains why the results show varying spillage for similar configurations. It may be associated with spillage from areas such as the burner flange that can be easily rectified.

3.0 Conclusions

Easy to Use Protocol – Useful Tool for Product Development

The main conclusion from this project is that a test is now available that allows manufacturers of oil-fired appliances to evaluate the effects of depressurization on their equipment at a reasonable cost. This test protocol has proven very useful in evaluating different design alternatives for effectiveness when subjected to a depressurized environment. The protocol and software included in this report can be easily and inexpensively adapted by other oil-fired appliance manufacturers. Kerr Heating Products has determined this capability can be an important tool for the development of oil-fired systems. Examples of this, which were demonstrated during this project, are the evaluation of different burner flange designs, the evaluation of several quick release vent couplings and the evaluation of a reversible breech low boy furnace.

Sensitivity & Repeatability

The sensitivity of the test is such that subtle differences cited in the above examples could be determined. Repeatability is good and well within the requirements of a test of this type. The test is very quick to perform once the appliance is set up. Warm air furnaces require a cool down time between tests. This cool down time can be reduced by turning the exhaust fan on high.

Some Oil Systems Can Withstand Significant Depressurization

Figure 1 shows that there are systems that pass the 2% spillage test, even when operated at 50 Pa depressurization. While there was a wide range of spillage results for the tested product/venting configurations, the 2% spillage limit used for this project was obtainable with good appliance and venting system design and good installation practices. Further work may be required to validate a 2% limit.

Venting Systems

Chimney vented appliances that used barometric dampers did not perform well above 5 Pa depressurization. This finding was expected, but it is important to note the appliance has little impact on the spillage since most occurs in the vent and through the barometric damper. Careful attention to sealing the smoke pipe

helps. Traditional smoke pipe does not perform well in a depressurized environment unless the joints are sealed with aluminum tape. A hybrid vent system taking combustion air from the room but venting into a sealed exhaust with no barometric damper offers much higher resistance to depressurization spillage than a conventional chimney vent. This venting approach appears to offer some promise for future products.

Current oil-fired direct vent technologies such as sealed combustion direct-venting, can meet a spillage requirement of 2% or less at 50 Pa depressurization when properly designed and installed. However direct venting has some problems related to venting out the sidewall. There appears to be good potential for developing and demonstrating an upgraded type of combustion venting system that would draw its combustion air from outside the house envelope while venting vertically, without using a barometric damper. This approach would have the advantages of current direct vent systems without the problems related to sidewall venting. This will be a subject for future study.

Burner Options

Although only four different burners were tested there are clearly vast differences among burner designs with respect to depressurization spillage. The approach to sealing the burner flange to the boiler or furnace also had a substantial impact on spillage. This information can be used by burner manufacturers to improve their depressurization performance. Two major oil burner manufacturers have expressed interest in this work and it is anticipated that burner depressurization performance will be improved in the future.

Value to Kerr

Kerr originally considered building a test facility that could be dismantled when not in use. Kerr has found the facility to be extremely useful during the product development cycle, and now uses it on a regular basis. Knowledge from depressurization testing has already been used to upgrade product installation practices and manuals.

Value to Oil Industry

Given the incidence of depressurizing homes is increasing and recognizing spillage of products of combustion products from oil-fired appliances creates both soot and odour, there is a significant opportunity for stakeholders within the oil industry to develop their own testing capability and to use it to reduce the risk of depressurization-related performance issues..

Appendices

A. Test Room Design

The design of the test room was a major task in this project. The design criteria were established based on the earlier work. Consideration was given to such parameters as portability, ease of construction, size, etc. Special consideration was given to criteria that would ensure ease of use for appliance manufacturers.

Size was one of the first parameters defined. Smaller is better because spillage will increase the background CO₂ level in the room and improve resolution of the test. A larger room will decrease the temperature change during the test. Small room size also reduces the influence of the CO₂ change in the room between the start and end of the test. As a point of reference the room at Bodycote for the earlier testing of gas-fired appliances was about 1600 cubic feet. This was selected as a nominal value for this project. This size did restrict the heat output of warm air furnaces that could be tested due to unacceptable temperature increases. This was thought to be acceptable since houses that have depressurization problems generally have lower heat loss and thus lower output appliances. In addition, oil-fired furnaces are normally designed and certified to operate with a range of burner inputs, so a depressurization spillage test could be performed on a furnace using a smaller nozzle.

There were several options considered for the design and construction of the test room. Bodycote used a “room within a room” concept. In the interest of expediency this project quickly focused on this option.

Some of the construction concepts considered are listed below. The first concept was 2 x 4 studs covered with polyethylene and sheet rock. This concept was designed so that it could be knocked down for storage and transport. Prefabricated structures such as shipping containers, trailers and sheds were also considered.

The test room had to have adequate access for moving appliances in and out. Hot water boilers can weight several hundred pounds so provision had to be made for some sort of load carrying device.

A decision matrix was used to select the two best concepts to pursue.

QUALITY FUNCTION DEPLOYMENT

TEST ROOM DESIGN

Alternative Design Options	Key Benefits					Value Ranking	Choice
	Cost	Ease of Set-up	Repeatability	Flexibility	Storage		
ATCO Trailer	2	5	5	1	1	50	
Used Shipping Container	4	5	4	1	1	80	
Metal Stud Construction	4	2	5	2	2	160	
Wood Stud Construction	4	2	5	2	2	160	
Custom Torsion Panel	4	3	5	4	5	1200	*
Modular Cold Room	1	4	5	3	5	300	
Used Modular Cold Room	4	4	3	3	5	720	*

The two top contenders, the custom torsion panel and the used modular cold room, were selected for further consideration. The torsion panels require significant labour to fabricate and construction accuracy is extremely important. A second-hand cold room of the appropriate size was located at a reasonable price. The cold room option was selected based on expediency, availability and robustness. Two types of cold room were available. One that is put together with screwed battens and one that uses Cam Lock fasteners. The Cam Lock design is much quicker to assemble and disassemble and was selected on this basis.

Initially the ability to easily break the room down for storage was believed to be an important consideration. After realizing the usefulness of the depressurization capability, the room is now an integral part of the lab and will not be taken down. Unless space is at a premium it is anticipated that most manufacturers would also want easy access to the depressurization capability. Therefore the option of not having Cam Lock fasteners would further reduce the room cost. The cost of the room with Cam Lock fasteners was \$3,400 for the panels and \$750 for the door.

The size of the room was 1205 cubic feet. This is similar to the volume used for testing gas-fired appliances. Although the output of warm air furnaces would be limited due to temperature rise it was considered acceptable.

The wall panels have a foam tongue on the bottom. Since the floor of the test room was to be the concrete floor of the lab, an interface piece had to be fabricated. In our case we took standard 2 x 4 lumber and cut a dado to match the tongue of the panel. The grooved 2 x 4's were then sealed to the concrete floor using caulk. This provided a solid base for the panels.

Some of the foam tongues were damaged and this will probably be true of most used rooms. Therefore the room joints were sealed with aluminum tape. This reduced leakage to an acceptable level.

Provision was made to allow controlled leakage into the room. This was done by installing HRV type grills that could be adjusted.

After completing many of the tests it was determined that a window in the room would be an advantage. This was added and sealed.

A picture of the room is shown below:



B. Test Instrumentation

The CO₂ monitors are the essential pieces of instrumentation for this project. Many options were assessed and the PP Systems WMO-1 was selected. More information is available at www.ppsystems.com. The two monitors were calibrated at the factory for 1000 ppm. The overall accuracy specification is better than 1.0%. These monitors performed extremely well as they were accurate, repeatable, reliable, and easy to interface to the data acquisition system. No drift was observed during the project and the two CO₂ monitors tracked each other.

Calibration gas for the CO₂ monitors was obtained from BOC Canada Ltd. The gas has CO₂ at 800 ppm ± 2%. More information is available at www.boc-gases.com.

The measurement of pressure across a flow element as well as differential pressure between the test-room and the surrounding space (depressurization level of the test room) is done using two-channel digital pressure, DG-2 Gauges from The Energy Conservatory. More information is available at www.energyconservatory.com. These meters were loaned to Kerr by CMHC and were calibrated before using them on this project. Digital manometers from Setra and Dwyer Instruments appear to meet all of the requirements at a reasonable price. More information is available at www.setra.com and www.dwyer-inst.com.

A laminar flow element (LFE) was selected as the device to measure the flow of air from the test room. This device is very accurate and rugged and is suitable for installation in a manufacturing environment. The LFE used is a model 50MC2-4 from Meriam. More information can be found at www.meriam.com. The main limitation to the LFE is that it achieves accurate flow measurement by generating a high pressure loss through it. This means a pressure blower must be used for depressurization.

The exhaust blower is a MMC Model PW11 with a 1 horsepower motor. This blower has radial blades and is capable of creating enough static pressure to work with the laminar flow element. The blower is a welded steel pressure blower from McMaster Carr. The catalog number is 1953K14. More information can be obtained at www.mcmaster.com.

The combustion gas analyzer used for this project is a Bacharach ECA 450. This analyzer is capable of handling several fuels and measuring NOx and SOx as well as the normal parameters. This analyzer is used to ensure proper appliance setup as well as determining the volume of combustion air going through the burner for chimney vent testing. The excess air measurement (EA) is used for this purpose. The RS232 port is used to transfer the data to the computer.

spreadsheet. Further information on the gas analyzer is available at www.bacharach-inc.com.

The computer is necessary to store and process the data. A serial port is required to allow data transfer from the gas analyzer. The computer must have Microsoft Excel.

The weight of fuel used is measured by an Ohaus CT1200-S digital scale. More information is available from www.ohaus.com.

The programmable logic controller (PLC) used for this project is a Koyo Digital Logic 205. The PLC was used to control the sequencing of events during the test. More information is available at www.automationdirect.com.

The CO₂ monitors and the digital pressure meters have analog outputs that are monitored with a data acquisition system. The data acquisition system used is an IOTech Personal Daq/50, Model 56. More information is available at www.iotech.com

C. Test Procedure

This is the standard procedure employed for depressurization testing using the equipment described in the previous section. The Kerr testing was controlled by a programmable logic controller (PLC). The PLC program is available from Kerr.

1. Install appliance in the test room in accordance with manufacturer's instructions.
2. Turn on all instrumentation including the data acquisition system.
3. Record atmospheric pressure (nearest Environment Canada Station).
4. Run depressurization blower and circulation fans in order to stabilize the CO₂ and temperature readings. The test room CO₂ and adjacent room CO₂ should be close to the same reading. If a test has been recently done a longer purge time will be required.
5. Record the fuel scale reading for the start weight.
6. Close chamber and adjust the depressurization blower to attain the required depressurization value. Confirm stable CO₂ readings and start logging combustion and test data for two minutes. The logging frequency is one measurement per second. Greater increments of up to five seconds can be used.
7. Initiate a call for heat.

8. Mark pre-purge end time.
9. Run burner for five minutes from the point of burner ignition.
10. Stop burner after five minutes and continue recording data for another two minutes. If the test room CO₂ continues to rise, continue recording data until it starts to decrease.
11. Terminate test and record the end fuel weight.
12. Enter required data to the spreadsheet on the “Test Info” worksheet.
13. Save data files under a unique name.
14. Run depressurization blower to cool room down.
15. Process data as shown in the next appendix.

D. Calculations

This section explains how to use the test data and spreadsheet to efficiently determine the amount of spillage for each test.

Users require a copy of Microsoft Excel or a compatible spreadsheet.

The calculations required for the determination of the depressurization spillage are quite extensive and are most expediently performed using a spreadsheet. The available CD contains two primary folders, DEP CH for the chimney vented tests and DEP DV for the direct vent tests. Each of these folders contains a spreadsheet, Chimney Matrix and DV Matrix respectively, that summarizes the data and is linked to the sub worksheets.

One important note is that the **"MROUND" function must be installed in Excel in order for the spreadsheet to work.** The spreadsheet template includes several tabbed worksheets that are described below.

The relative humidity is determined from an algorithm from Weather World at http://members.alo.com/Accustiver/wxworld_calc.html.

“Test Info” (Worksheet 1)

This sheet contains: depressurization value, date, sample number, appliance information, vent information, burner type, nozzle size, mass of oil used, barometric pressure, test room volume and comments. The barometric pressure is input based on the nearest Environment Canada station. All data on this sheet are input manually.

“Test Data” (Worksheet 1)

This sheet contains test information transferred **automatically** from the “Test Info” sheet. It also contains the test data input from the data acquisition system. The time, the time increment, laminar flow element (LFE) pressure differential, test room CO₂, adjacent room CO₂, LFE temperature, room wet bulb temperature, room dry bulb temperature, oil temperature, system on/off status, burner fired status, and log trigger. All input to this sheet is automatic.

The “Combustion Data” sheet contains information generated by the gas analyzer. The only data used in the calculation of spillage is the Excess Air (EA) and this is only used for non-direct vent tests where combustion air comes from the test room itself. The Excess Air is converted to volume of air removed from the room.

The “Hum Cor Fact” sheet is a lookup table used to determine the correction factor to account for relative humidity of the air for the laminar flow element. The lookup table is an expansion of Table A-35600 given in the Meriam Laminar Flow

Element Installation & Operating Instructions. The table has been expanded using linear interpolation for both relative humidity and temperature.

The “Averages” sheet collects the raw data and computes the 15 second averages. Oil burners often have a pre-purge cycle that must be taken into account when determining the start of the test. A programmable logic controller (PLC) is used for this purpose. The actual burner start time is used as the test start. The CO₂ values for the room and adjacent room are averaged and the difference from the base lines is determined. The average pressure differential across the LFE is calculated. The room wet and dry bulb temperatures are averaged as well as the LFE temperature.

The “Calcs” sheet contains the data resulting from calculations using the averaged data. The test information is transferred to this sheet. There are three fields that require user input only once providing that the same laminar flow element is used. These inputs are the calibration factors for the laminar flow element. The inputs are B and C that are coefficients of the calibration curve and viscosity constant. These values are provided by Meriam for each individual laminar flow element. The “Row Ref. From Averages” links the “Calcs” information with the “Averages” sheet. The exhaust fan flows are calculated from the laminar flow element. Conversion is made the standard cubic feet per minute. The relative humidity is computed from the average data. The temperature and relative humidity are then rounded and used to calculate the correction factor from “Hum Cor Fact”. The excess air from the “Combustion Data” sheet is averaged and used when the combustion air is taken from the test room. Note that the values from the gas analyzer are processed to eliminate “outliers”. The air density is calculated for the start and end of test to account for density changes due to temperature.

The “Char Test Data” sheet plots many of the parameters as a function of time.

The “Calcs Summary” sheet presents a summary of all of the pertinent data. The information for the 15 second increments is displayed and the final calculations are performed. The spilled CO₂ is calculated and the percent spillage computed. If combustion air is taken from the room the air consumed by the burner is determined.

Detailed Test Results

Detailed test results are included in the available CD. A summary of all of the tests is shown in the table below:

SUMMARY OF TEST RESULTS

Configuration			Comments	Depressurization (Pa)	Spillage (%)
Platform	Burner	Vent			
K6 Summit Furnace	Burner 1	Chimney	Extended Vent, Barometric	5	1.4
K6 Summit Furnace	Burner 1	Chimney	Extended Vent, No Barometric	5	1.2
K6 Summit Furnace	Burner 1	Chimney	Short Vent, Barometric	5	1.0
K6 Summit Furnace	Burner 1	Chimney	Short Vent, No Barometric	5	1.2
K6 Summit Furnace	Burner 1	Chimney	Extended Vent, Barometric	8	8.8
K6 Summit Furnace	Burner 1	Chimney	Extended Vent, No Barometric	8	3.9
K6 Summit Furnace	Burner 1	Chimney	Short Vent, Barometric	8	3.0
K6 Summit Furnace	Burner 1	Chimney	Short Vent, No Barometric	8	2.6
KM Eclipse Furnace	Burner 1	Chimney	Extended Vent, Barometric	5	5.5
KM Eclipse Furnace	Burner 1	Chimney	Extended Vent, No Barometric	5	2.1
KM Eclipse Furnace	Burner 1	Chimney	Short Vent, Barometric	5	3.8
KM Eclipse Furnace	Burner 1	Chimney	Short Vent, No Barometric	5	1.8
KM Eclipse Furnace	Burner 1	Chimney	Extended Vent, Barometric	8	13.6
KM Eclipse Furnace	Burner 1	Chimney	Extended Vent, No Barometric	8	6.7
KM Eclipse Furnace	Burner 1	Chimney	Short Vent, Barometric	8	8.2
KM Eclipse Furnace	Burner 1	Chimney	Short Vent, No Barometric	8	3.4
KM Eclipse Furnace	Burner 1	Chimney	Flex Vent to Chimney, Combustion Air from Room, No Barometric	5	0.1
KM Eclipse Furnace	Burner 1	Chimney		8	1.1
KM Eclipse Furnace	Burner 1	Chimney		20	8.2
KM Eclipse Furnace	Burner 1	Chimney		50	20.6
Comet 95 Boiler	Burner 1	Direct Vent	Standard DV, Quick Disconnect	50	2.5
Comet 95 Boiler	Burner 1	Direct Vent	Standard DV	50	2.1
Comet 95 Boiler	Burner 2	Direct Vent	Standard DV, Burner Flange Not Sealed	50	7.0
Comet 95 Boiler	Burner 2	Direct Vent	Standard DV, Burner Flange Sealed	49	3.0
Comet 95 Boiler	Burner 2	Direct Vent	Standard DV, Burner Flange Not Sealed	20	3.6
Comet 95 Boiler	Burner 2	Direct Vent	Standard DV, Burner Flange Sealed	19	1.0
Comet 95 Boiler	Burner 3	Direct Vent	Standard DV	50	3.5
Comet 95 Boiler	Burner 3	Direct Vent	Standard DV	20	1.5
K6 Summit Furnace	Burner 4	Direct Vent	Standard DV, Downflow	50	4.0
KM Eclipse Furnace	Burner 4	Direct Vent	Standard DV	50	2.5
KM Eclipse Furnace	Burner 4	Direct Vent	Standard DV	20	0.6

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