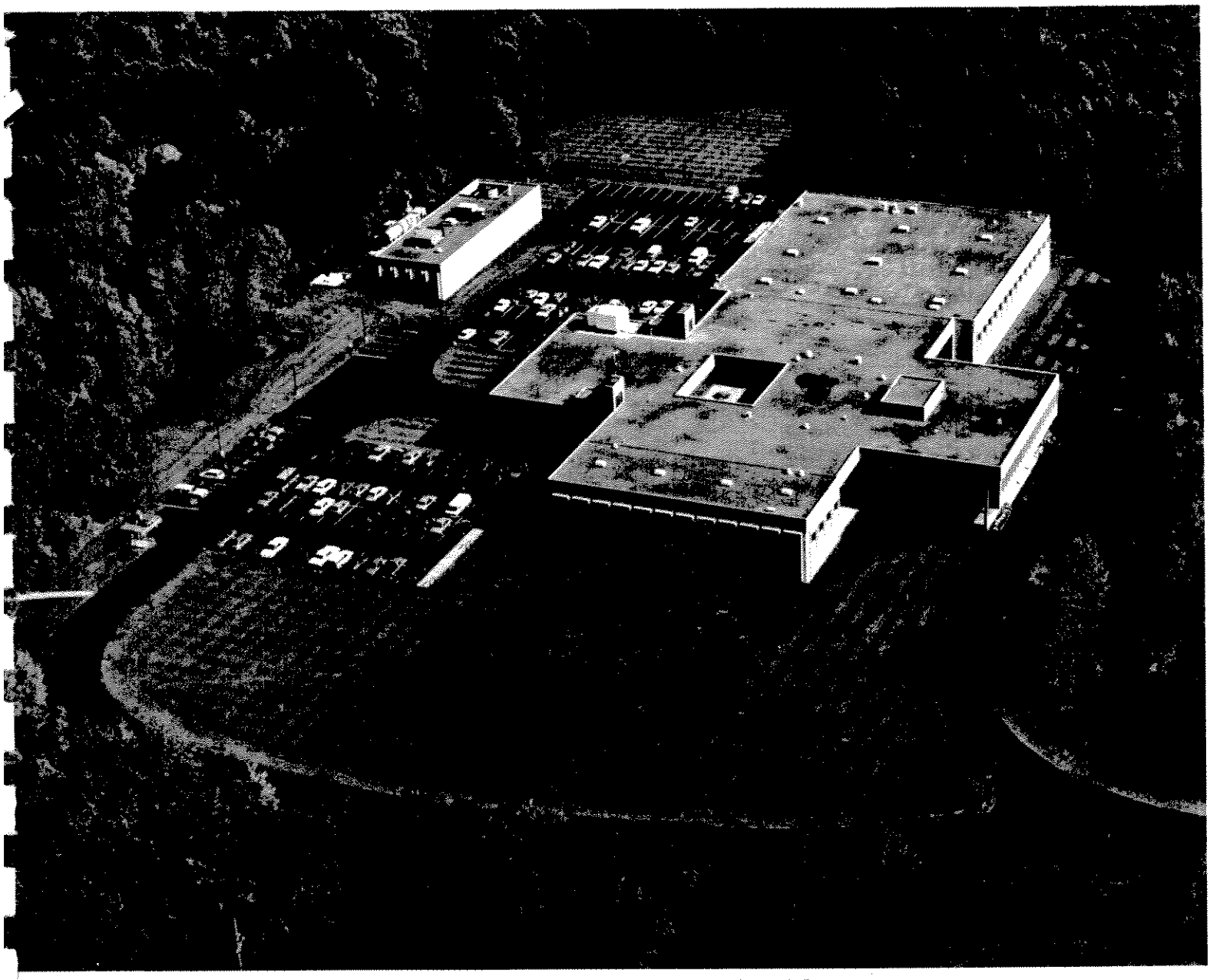


REPORT NO. FT-C-07-93
ON PERFORMANCE OF DRAFTHOOD EQUIPPED GAS APPLIANCES MODIFIED BY THE ADDITION OF BAROMETRIC DAMPERS

A.G.A. LABORATORIES FIELD TEST PROGRAM

PREPARED FOR THE FIELD CONTROLS COMPANY

A Field Test Report is not equivalent to product design certification. The factual information provided is intended only to assist code enforcing authorities, and others involved in judging acceptance of the device for use in their area of jurisdiction.

REPORT NO. MEA FT-C-07-93

REPORT ON EQUIPMENT FIELD SAFETY TESTING/EVALUATION BY INTERNATIONAL APPROVAL SERVICES, AMERICAN GAS ASSOCIATION LABORATORIES, CLEVELAND, OHIO ON DRAFT HOOD EQUIPPED GAS APPLIANCES MODIFIED BY THE ADDITION OF DOUBLE ACTING BAROMETRIC DAMPERS.

TESTING REQUESTED BY: Steve Guzorek
Vice President, Engineering
The Field Controls Company

REPORT DATE: November 1, 1993

TESTING LOCATION: Testing was conducted at the unit installation sites listed herein and at the manufacturer's laboratory facility located at 2308 Airport Rd., Kinston, North Carolina 28501.

PREVIOUS OR PRESENT CERTIFICATIONS: Designs of all of the gas appliances utilized for this evaluation were in their original configuration (as built) and as originally certified by the American Gas Association Laboratories (A.G.A.L.). The Field Controls Co. dampers utilized are listed by Underwriters Laboratories (UL). This information was verified by data plate information.

TEST UNITS: This report only applies to the unit installations listed herein and as installed at the testing locations identified above in the report.

EXTENSIONS: Acceptance of or extension of results of testing herein contained to similar units or installations installed or placed at other locations becomes the responsibility of the jurisdiction or person making such a decision. Such decisions are outside the scope and purpose of this testing program.

TEST PURPOSE: The purpose of testing herein described was to have verification from a third, impartial party, of performance results obtained when certain draft hood appliances and appliance installations are modified by the addition of barometric dampers. Testing was intended to monitor equipment performance before and

after conversion. The main areas investigated, addressed safety related issues pertaining to changes in combustion related characteristics such as carbon monoxide formation (both measured and air free calculated), flue gas spillage, venting, and carboning. Incidental other non safety related data such as efficiency changes based on undiluted (sample taken ahead of draft hood or barometric damper) flue oxygen and carbon dioxide levels were also recorded. Field Controls Company intends to utilize the results for product engineering and development, product acceptance, and for informing and educating jurisdictional and codes authorities.

NOTICE: This report applies to the design in the configurations only as tested at the herein identified locations. The report can only be published or issued as a complete entity and no abstracts or abbreviations are permitted. The report cannot be used or in any way presented or proffered as evidence of certification. The information provided is intended to provide the user and any code enforcing authorities and others involved in judging acceptance of the products covered by this report and also to assist in further research and product engineering.

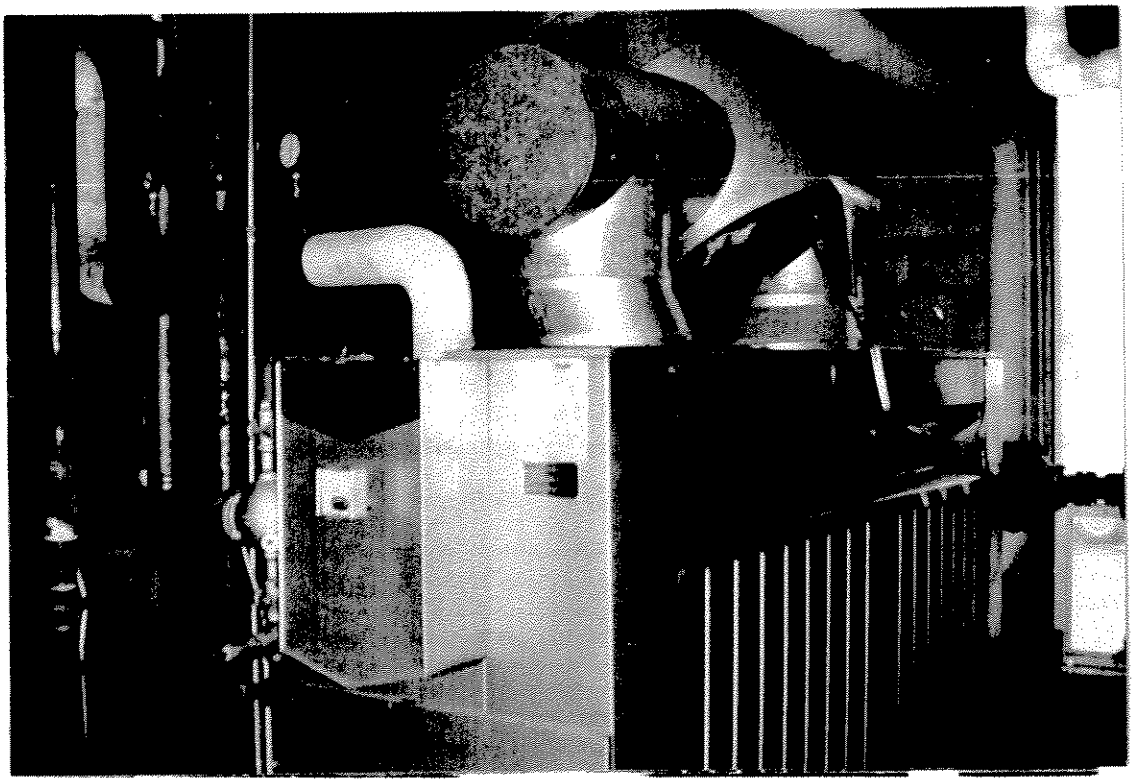
FORMAT: This published report consists of eighteen (18) sequentially numbered pages. Contracts for field testing, testing data, and related documentation are on file at the American Gas Association Laboratories, 8501 East Pleasant Valley Road, Cleveland, Ohio 44131. Said material will be retained for a period of ten (10) years from the date of the report shown above.

INSTALLATION DESCRIPTIONS: Equipment installed at the following sites was evaluated for this report.

Field Test Sites

Addresses*	Type of Equipment	Approximate Age	Appliance Input Rate Btu/Hr
Site 1 Private Residence Northfield, Ohio	Upflow Forced Air Furnace Atmospheric	3 yrs	125,000
Site 2 Small multifamily residential apartment bldg. Akron, Ohio	Five boilers, Atmospheric Common Vented	5+ yrs " " "	2 @ 62,000 1 @ 37,500 1 @ 96,000 1 @ ? (could not be determined)
Site 3 Commercial Establishment Akron, Ohio	Commercial Water Heater Atmospheric	2 yrs.	520,000
Site 4 Hotel Equipment Room #1 Canton, Ohio	2 @ Boilers - Atmospheric 2 @ Comm. Water Htr - Atmospheric	15 yrs & 19 yrs 3 yrs	1,375,000 (min) 2,750,000 (max) 800,000 197,000 250,000
Site 5 Hotel Equipment Room #2 Canton, Ohio	2 @ Boilers - Atmospheric	<5 yrs	2,000,000@
Site 6 School Building Boiler Room Perry, Ohio	6 @ Boilers - Atmospheric	<5 yrs	1,119,000@

*Actual site addresses are on file at A.G.A.L.



ORIGINAL CONFIGURATION SITE NO. 4. MULTI-RATE HOT WATER BOILER NOTE DRAFT HOOD RELIEF OPENING WITH INDICATIONS OF SPILLAGE

TESTS AND EVALUATION CRITERIA:

Testing was conducted using portions of the following American National Standards Institute (ANSI) standards and other standards listed below as guidance and also based on the recommendations of experienced certification test engineers of the American Gas Association Laboratories:

Standard Numbers	Titles
ANSI Z21.10.3-1990	Commercial Water Heaters
ANSI Z21.13-1991	Boilers
ANSI Z21.47-1990	Central Furnaces
ANSI Z223.1-1992	National Fuel Gas Code

RATIONAL FOR TESTS: When possible, testing procedures equated to requirements of the above standards; however, in order to demonstrate the condition of concern to the program requestor (such as build up of CO levels over time), sample times did not correspond exactly to times specified in the standards. There were no changes in the methods for CO limit and air free calculations from values determined by the referenced standards.

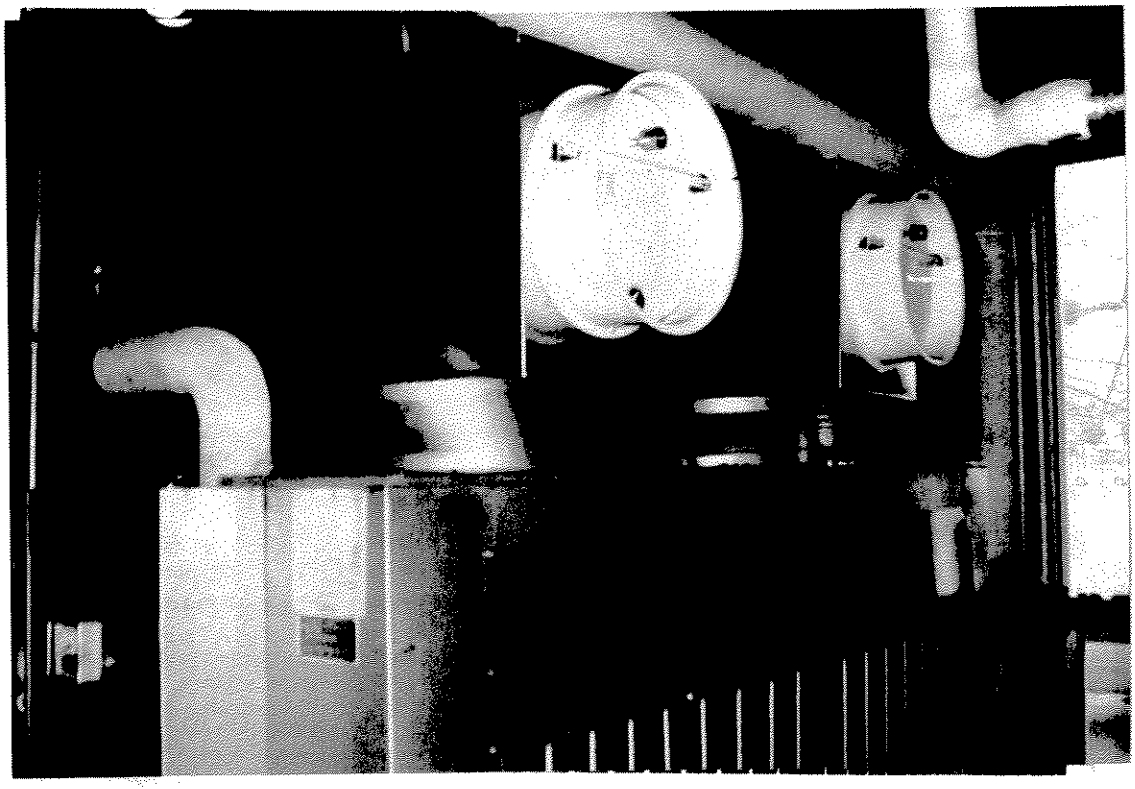
SITE NO. 4 SEALING DRAFT HOOD RELIEF OPENING AS PART OF CONVERSION

TESTING CONFIGURATION: Testing was conducted in two stages. The first stage consisted of field testing at various northern and Mid-Ohio locations in mid March, 1993. The test sites were selected on the basis of ongoing appliance performance investigations which were being conducted by various servicing organizations and local agencies. The second stage was completed in July 1993 at the Field Controls Engineering Labs in Kinston, North Carolina. At this site, specific items could be investigated under controlled laboratory conditions.

On site field testing was conducted in the original installed configurations without any modification of the units or the installation except for either blockage or removal of the original draft hood and the addition of the barometric dampers and any needed vent piping.

TYPE OF GAS OPERATION: In Ohio: Natural gas service as provided on site by the local gas distribution utilities.

Gas at the Kinston, North Carolina: Provided by North Carolina Natural Gas Corp. along with an analysis and heating value print out verifying composition and BTU contents.



SITE NO. 4 CONVERTED TO OPERATION WITH FIELD CONTROLS DOUBLE ACTING BAROMETRIC DAMPERS

TEST EQUIPMENT AND INSTRUMENTATION:

- A Siemans Ultramat #22P, a Test-O-Term Model No. 342-3 and an Enerac Model No. 2000 portable combustion gasses analyzer and temperature and draft indicator
- Validyne Model No. PS309 calibrated digital pressure gases
- Epselon/Lambda Electronics Corp. Model No. NGX-5 gas leak detector
- Fluke Model No. 8022A multimeter (VOM meter)
- Biddle Instruments Catalog No. 21154 Meggar tester
- J and N Associates Inc. Trak-it combustible gas indicator
- Omega Engineering Inc. Model No. HH-30 portable air velocity meter, (digital anemometer)
- A Marlin Thermicator No. 402A potentiometer, Type J
- Calibrated temperature probes and thermocouple wire
- Variable transformer

TEST AND EVALUATIONS CONDUCTED:

The following tests were conducted in accordance with requirements stated in the previously referenced standards. Where test procedures could not be controlled to totally duplicate the standard requirements, the purpose of testing was still maintained to provide the results of testing as intended by the requirements.

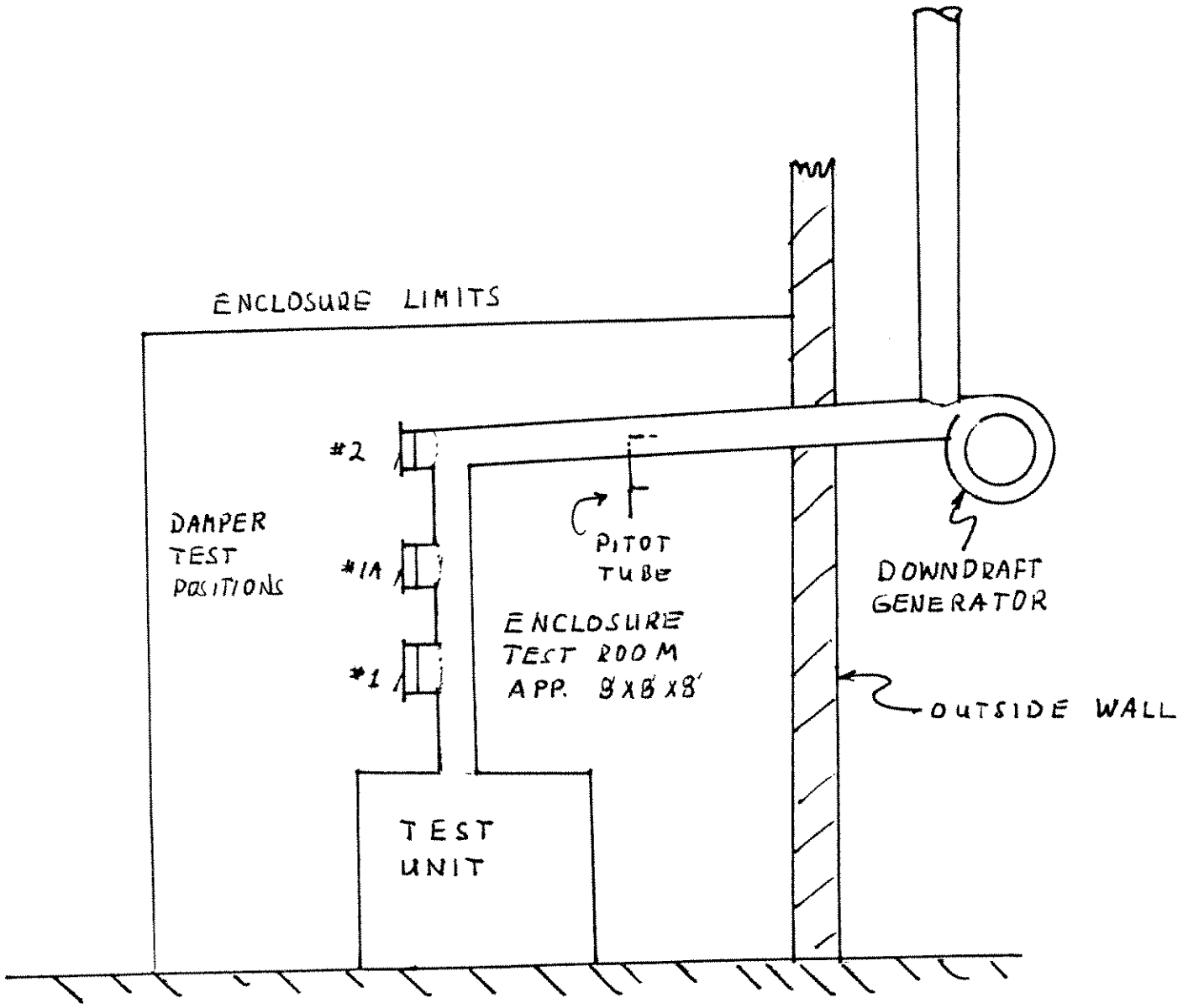
Testing was divided into two phases.

The first phase consisted of an on site tests at established appliance installations. At these sites normal combustion tests were conducted first in the original configuration (with draft hood) then with the same unit after the draft hood was replaced by a double

acting barometric damper. All appliance modifications on site were done directly by or under the supervision of qualified trained service professionals equipped with functioning instruments such as combustion gases analyzers and draft measuring devices. A check of their instruments was periodically conducted by utilizing the Laboratories certification capable equipment.

The second phase of testing was conducted at the laboratory facilities of Field Controls in Kinston, North Carolina. This phase of comparative testing consisted of a program of normal combustion with draft hoods, blocked flue combustion with draft hoods, and down draft combustion testing. The same tests were then repeated but with the draft hood blocked and/or replaced and with a double acting barometric damper. Firing rates and, main burner and pilot operation charac-teristics were also verified for every test condition.

During the second phase of the program, testing was conducted on three basic appliances, 2 @ A.G.A. listed hot water boilers and an oil-fired boiler was converted to natural gas operation by an A.G.A. listed power burner. When in the course of the testing the factory supplied draft hoods were changed out with double acting barometric dampers, the barometric dampers were installed in three different configurations on the vent as identified in the enclosed sketch.



SKETCH OF SET UP

TEST RESULTS - Installation Sites

		UNIT WITH DRAFT HOOD				UNIT WITH BAROMETRIC DAMPER			
Test Site Number	Type of Appliance	CO ppm Before d.h.	CO_2% Before d.h.	CO ppm Air Free	Comments After d.h.	CO ppm Before b.d.	CO_2 Before b.d.	CO ppm Air Free	Comments
1	Upflow type forced air furnace	112	8.0	171	3 minute sample	20	6.4	38	3 minute sample
2	Residential boilers #2	75	8.7	105		15	7.6	24	
3	Commercial water heater	280-415	3.4	1004 to 1489		20	6.0	41	
4	Commercial Boiler #1	**	**		Unit spilled from d.h. for 3 minutes	59 right 59 left	6.3 right 5.6 left	114 129	D.h. spillage corrected when damper added
4	Commercial Water Heater #1	>3500	10.2	>4186	Draft -.00 sooting common vent with boiler #2	265	8.5	380	Possibility of accumulated soot also burning off as CO
4	Commercial Boilers #2	80	5.5	177	Common Vent with above	11	4.9	27	
5	Commercial Boiler #1 Commercial Boiler #2	1248 left 266 right 510 left	5.6 5.3 5.2	2719 left 612 right 1197	Draft 0.0" below d.h. calm day	131 left 113 right 30 left 62 right	5.1 5.0 5.0 3.8	313 left 275 right 73 199	Draft - .01 to -.05 windy day draft -0.01 to -0.05 - windy day
6	Commercial Boiler #1 Boiler #2 Boiler #3	112* 18 - 650* 18 - 650* 128 - 650*	5.7 7.6 to 5.7 7.6 to 5.7 7.6 to 5.7	240 39 to 1391 " "	Draft .01 Less than 600 $in.^2$ air opening inlet to room Six identical boilers in room	7 15 12	6.4 5.3 6.3	13 35 23	Units 1, 2 & 3 operated concurrently for CO reading

b.d. = barometric damper
ppm = part per million
d.h. = draft hood

** Short run time not valid for CO/CO_2 readout. Unit was shut off, spilled from d.h. 3 minutes.
* With only one unit on. With all units on, CO varied with time from 18 to 650 ppm

COMPARATIVE TESTING - AT FIELD CONTROLS LABORATORY FACILITY

WITH DRAFT HOOD (DH)						WITH DOUBLE ACTING BAROMETRIC DAMPERS					
TEST UNIT NO.	Test Type	Carbon Monoxide ppm	Carbon Dioxide Percent	Air Free ppm Carbon Monoxide	Comments: Draft Hood Tests	Damper Location Position #	Test Type	Carbon Monoxide ppm	Carbon Dioxide percent	Air Free ppm Carbon Monoxide	Comments: B.D. Tests
1	NC	38	6.1	76	Vertical Cone Type D.H.	2	NC	9	5.5	20	Damper 36" above unit jacket
1	BF	41	6.2	81	Vertical Cone Type D.H.	2	BF	17	5.9	35	"
1	DD 0.013	39	6.2	77	Vertical Cone Type D.H.	2	DD 0.024	66	6.7	120	"
1	NC	38	6.5	71	Vertical Cone Type D.H.	2	DD 0.05	498	7.6	799	
1	DD 0.05	45	6.4	86	Vertical Cone Type D.H.	1 1 1 1	N BF 0.028 DD 0.05 DD	17 27 168 2166	5.6 6.0 7.3 7.8	37 55 281 3388	Damper 25" above unit jacket
2	NC	41	7.9	63	Integral D.H.	1	NC	10	7.0	17	7" MG1 Damper
2	BF	477	9.0	647	Integral D.H.	1	BF	257	9.2	340	7" MG1 Damper
2	DD .02	956	6.7	1741	Integral D.H.	1	0.015 DD				Flame Roll Out-Shut Down
2	DD .05	890	6.2	1751	Integral D.H.	2 2 2 2 2 2 2 2	NC BF 0.02 DD 0.02 DD 0.05 DD 0.011 DD NC 0.011 DD	4 34 3401+ 3392+ - 3283+ 0 3283+	6.5 8.4 9.7 9.3 - 8.1 6.7 8.1	8 49 4227+ 4450+ -* 4945+ 0 4945+	Repeat Check Test *Unit Shutoff by Flame Switch and Flame Sensor Reversed Damper Blade Reversed Damper Blade
3	NC	25	7.4	41	Integral D.H.	1	NC	0	5.3	0	
3	BF	299	7.8	468	Integral D.H.	1	BF	68	7.4	112	
3	NC	0	6.4	0	Repeat of previous N.C.						
3	DD 0.018	17	7.3	28	Integral D.H.						
3						2	NC	0	5.4	0	6" baro. damper
3						2	BF	335	8.8	464	6" baro. damper
3						2	DD 0.013	3289+	8.8	4560+	6" baro. damper
3						2	NC	8	5.2	19	7" baro. damper
3						2	DD 0.016	3134+	7.4	5167+	7" baro. damper
3						1A	NC	2	4.9	5	6" baro. damper
3						1A	BF	156	7.5	254	6" baro. damper

Usual protocol for downdraft test requires combustion at .02" and .05 downdraft. Barometric dampers generally are totally open under down draft of 0.01".

Unit #1 - Oil fired boiler, converted with natural gas power burner, input rat 73,677 Btu/hr

Unit #2 - Hot water boiler, 210,000 Btu/hr input, atmospheric burner, draft hood equipped (integral)

Unit #3 - Hot water boiler, 163,000 Btu/hr input, atmospheric burner, draft hood equipped (integral)

Test Condition - NC = normal combustion, BF = blocked flue combustion, DD = down draft combustion

+ = Rendered outside of instrumentation limits

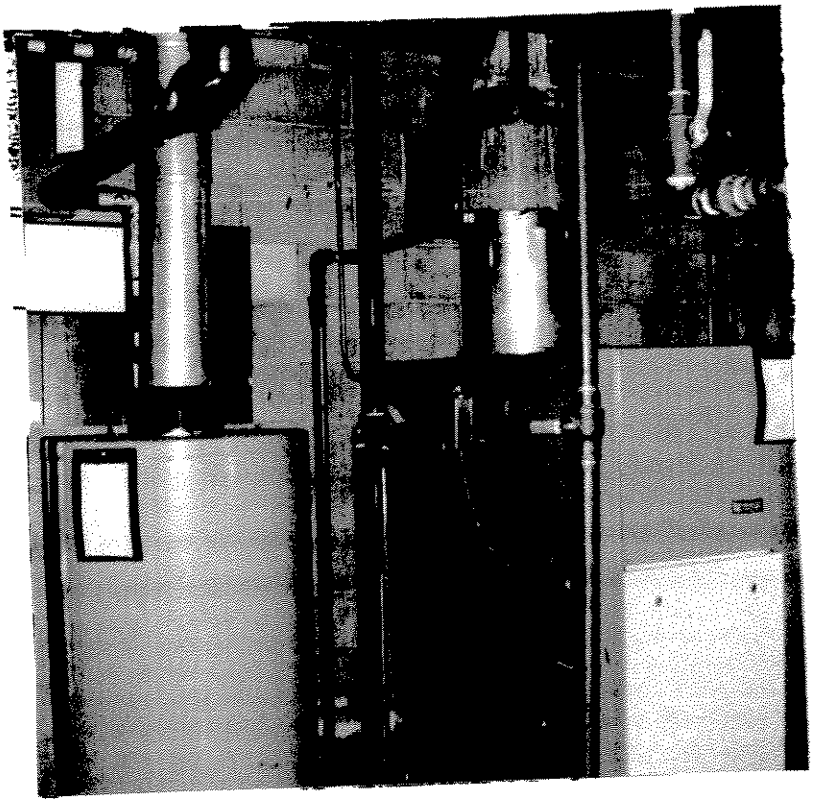
Data was also collected by a Bacharach Model No. 300 combustion analyzer which was periodically verified to be accurate by comparison to A.G.A. certification equipment.

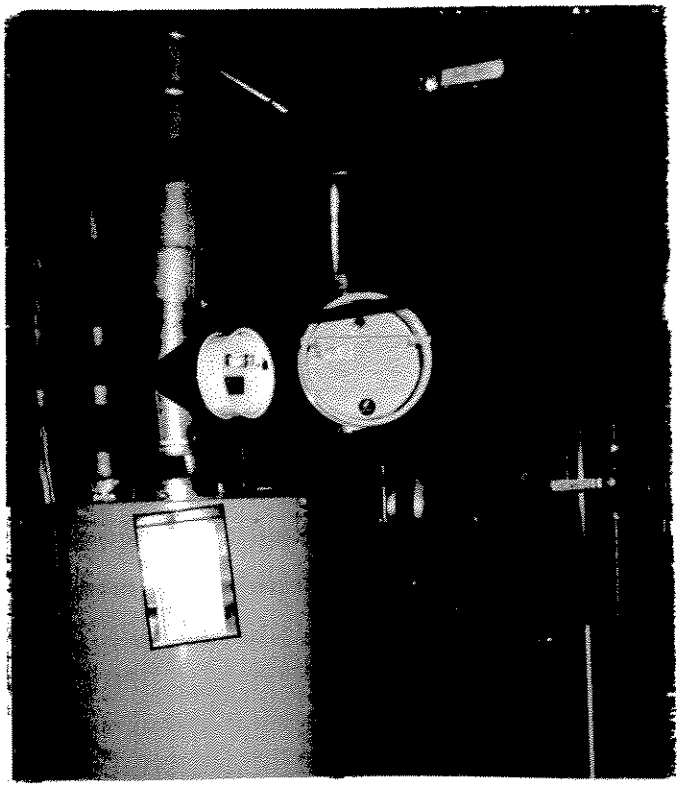
Test results are summarized on the enclosed tables.

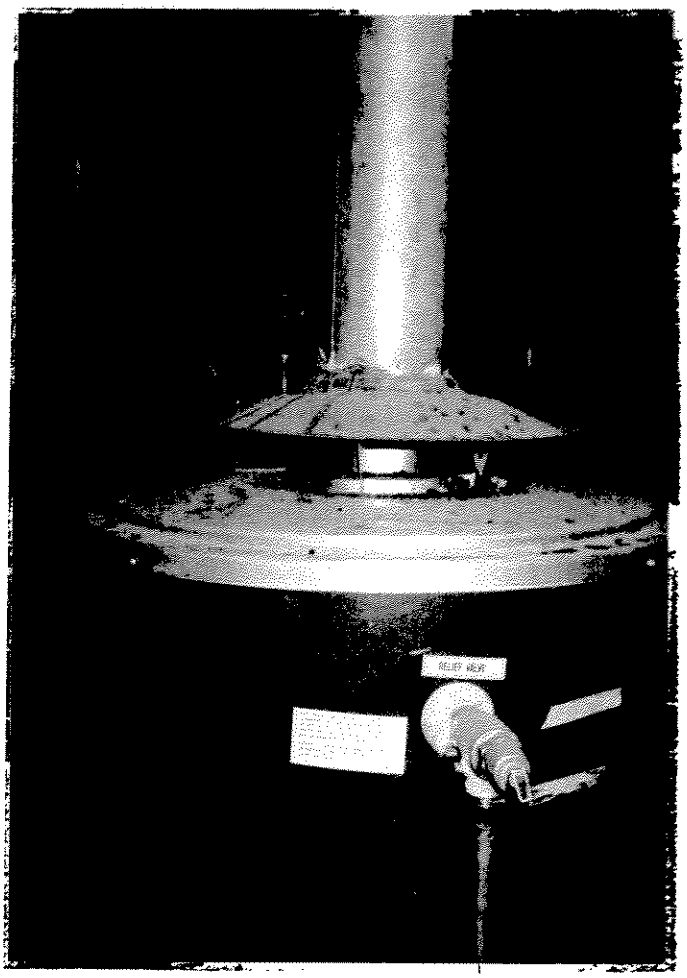
The table entitled "Test Results - Installation Sites" lists combustion data obtained at the original equipment sites. It should be noted that in all instances given, when barometric dampers were retro-fitted, appliance combustion safely increased as evident by lower carbon monoxide (CO) readings. All instances of operation appliances outside of the 400 parts per million (ppm) CO air free (stoichiometric) limit set by the referenced standards were found to be significantly corrected and brought back to within the limits. (Test site No. 3 - water heater, No. 4 - water heater, No. 4 and No. 5 - boilers). It should be noted that the placement of barometric dampers and related engineering judgement was conducted by qualified service professionals utilizing suitable equipment to re-enforce their decisions.

The results of comparative testing under laboratory conditions also indicated improved appliance performance for CO safety with the notable exception of down draft test conditions. The results obtained under forced down draft conditions point to a need to minimize the effects of down draft conditions on the operation of barometric damper equipped appliances.

Possible solutions to minimize the effects of downdraft on appliances equipped with barometric dampers are; vent spill switches mounted to barometric dampers, (Vent spill switches are very adaptable to effective mounting to barometric dampers since installation of the devices in the spill stream path of the flue products is easily controlled), flame roll out switches, (presently required for furnaces and boilers) and, vent termination designs limiting down draft. Other approaches not listed are also possible.



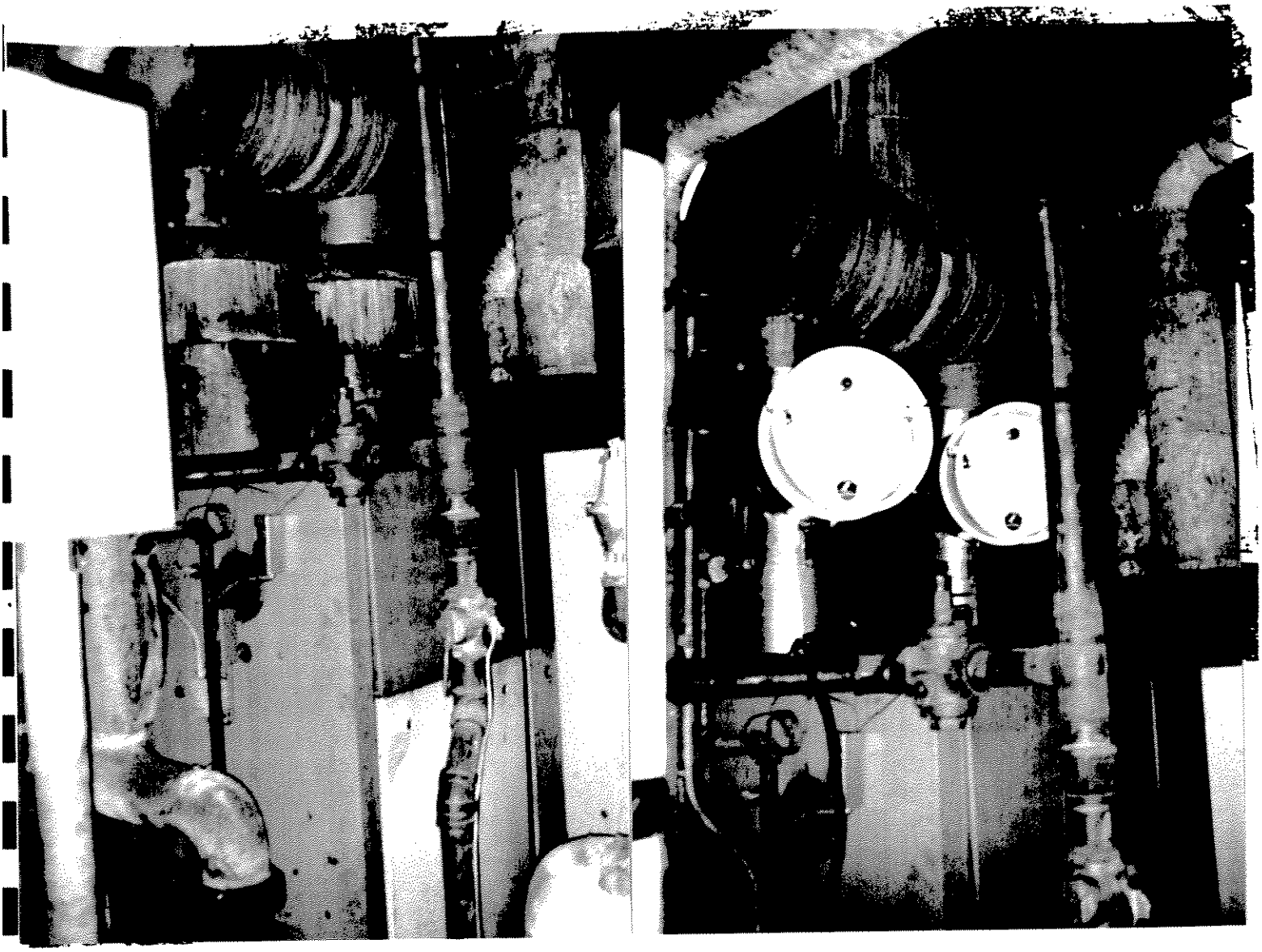




SITE NO. 4.

TOP LEFT AND RIGHT - WATER HEATER AND BOILER BEFORE AND AFTER CONVERSION TO OPERATION WITH BAROMETRIC DAMPERS

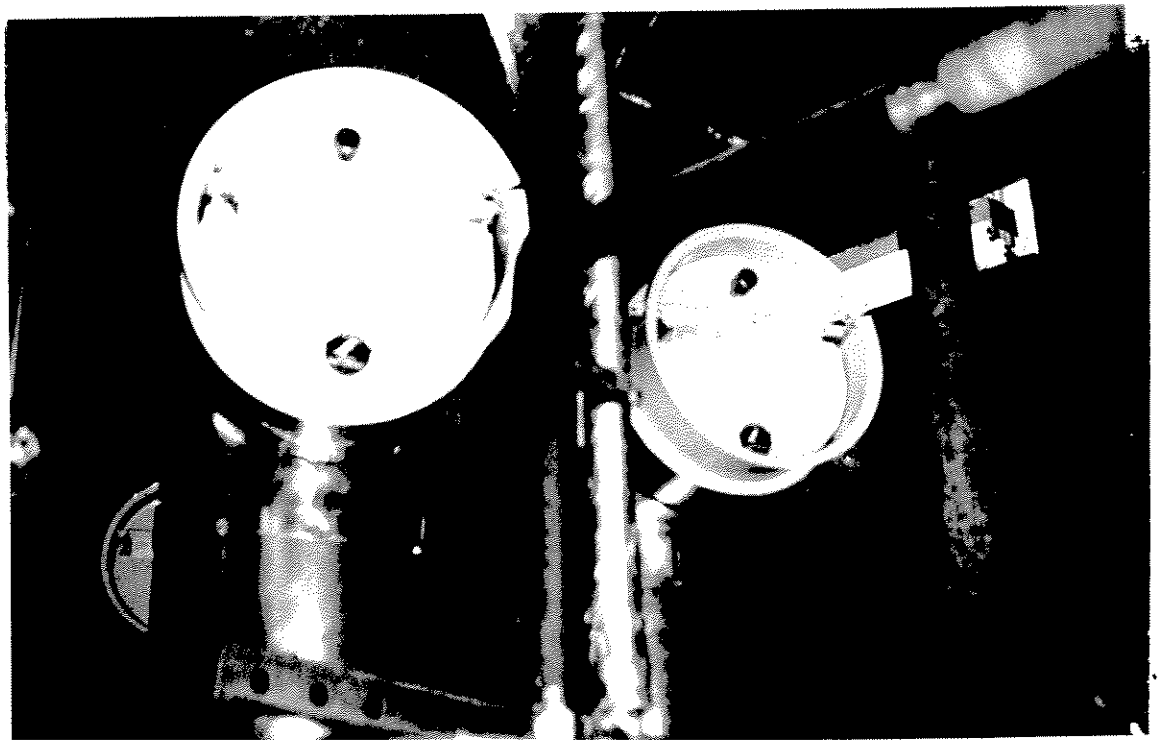
BOTTOM RIGHT - WATER HEATER BEFORE CONVERSION. NOTE EVIDENCE OF COMBUSTION PROBLEMS AS EVIDENCED BY SOOT DEPOSITS BELOW HOOD



TOP - WITH ORIGINAL DRAFT HOODS

BOTTOM - CLOSE-UP OF INSTALLED DAMPERS

TOP RIGHT - WITH BAROMETRIC DAMPERS



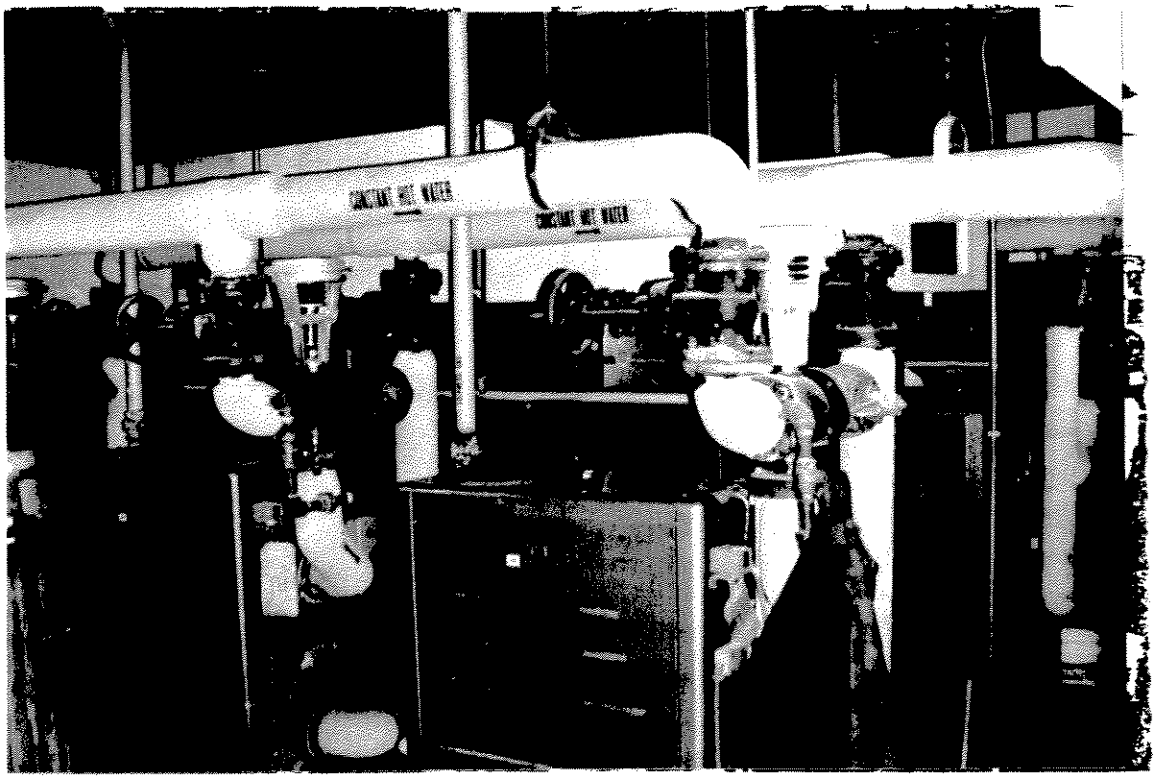
SITE NO. 5.

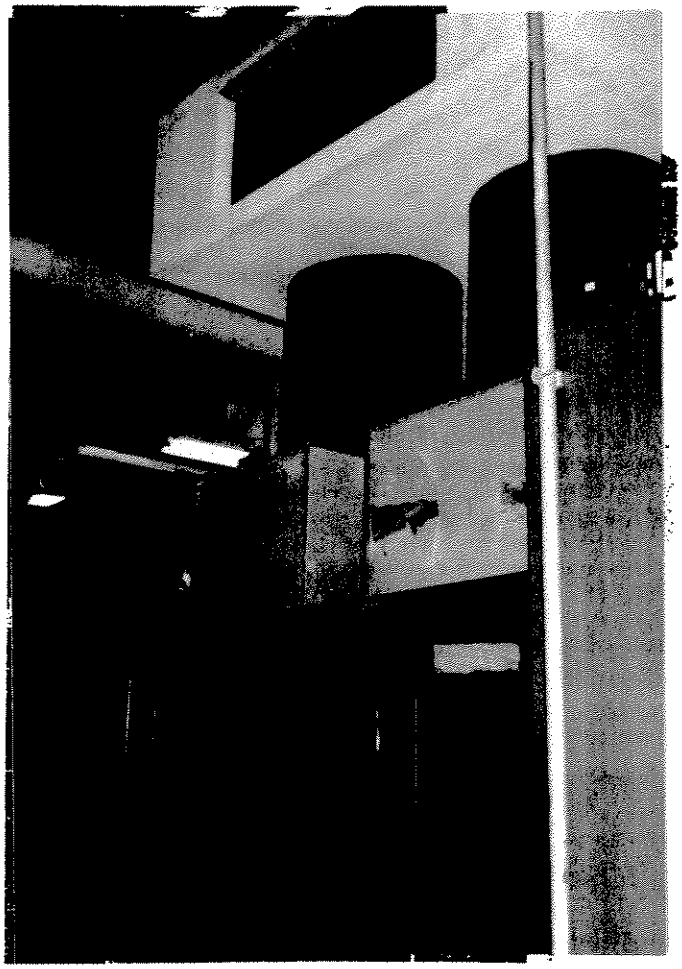
SITE NO. 6.

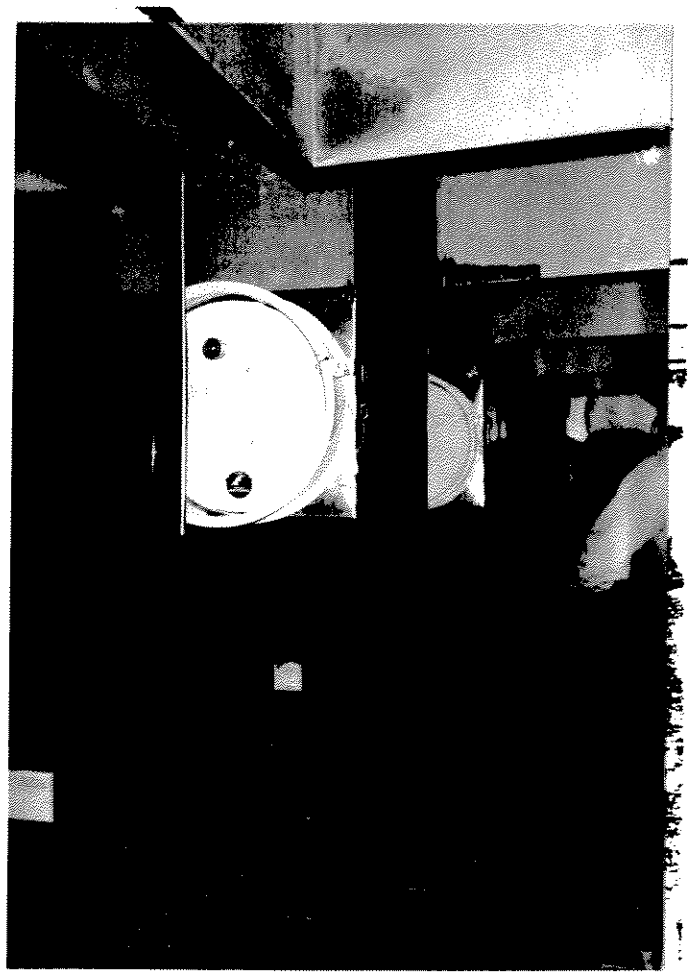
RIGHT - VIEW OF SIX BOILER INSTALLATION

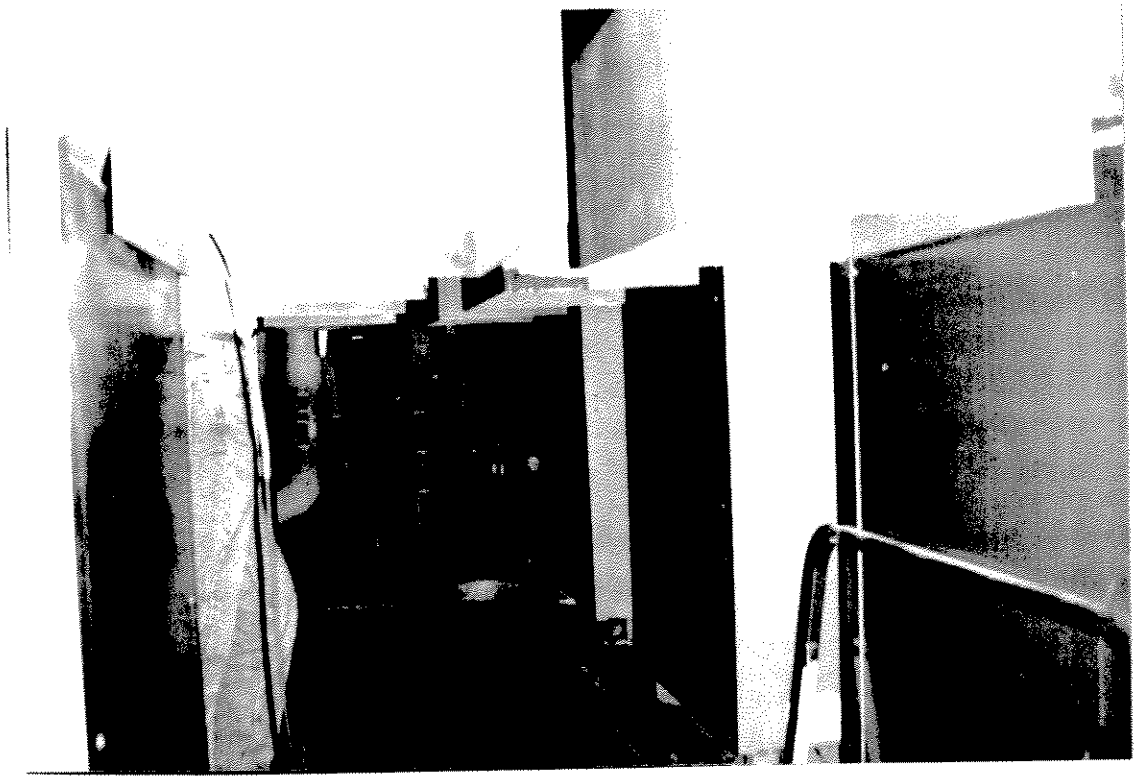
BOTTOM LEFT - BEFORE CONVERSION

BOTTOM RIGHT - SAME AREA AFTER ADDITION OF TWO BAROMETRIC DAMPERS. NOTE OPEN DRAFT HOOD RELIEF OPENINGS ON UNCONVERTED UNITS.

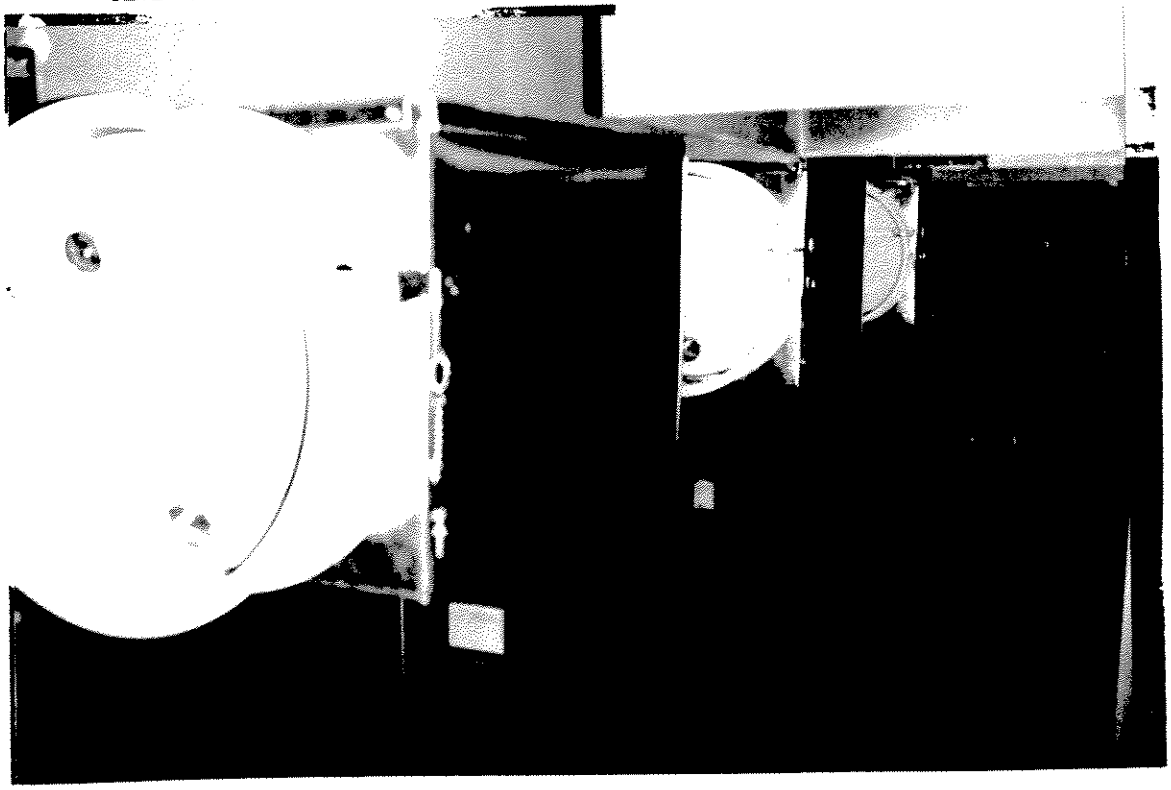


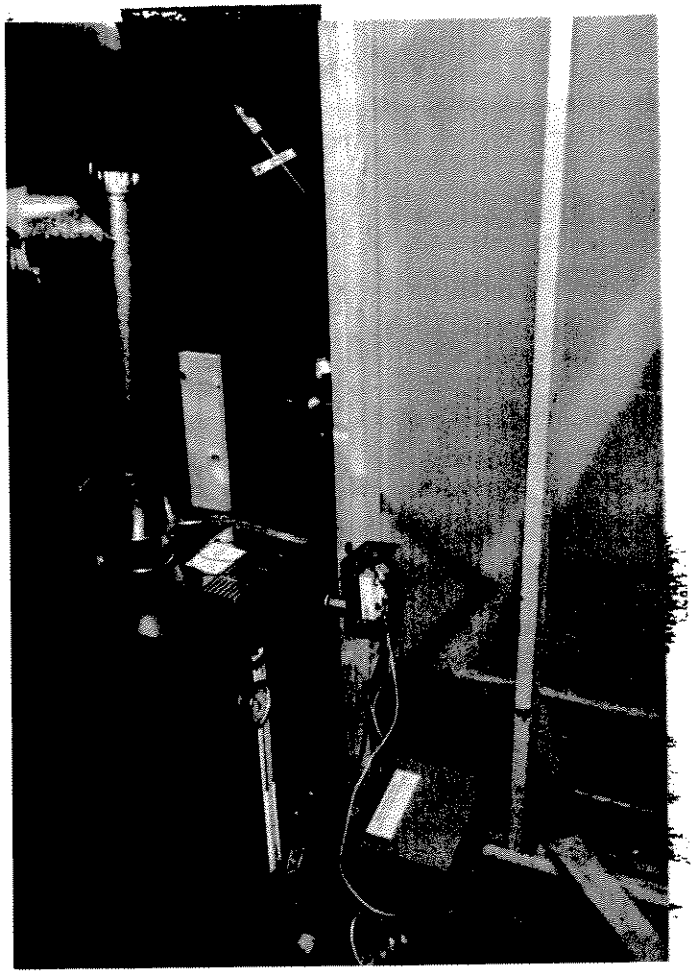






SITE NO. 6.
TOP - BEFORE CONVERSION
BOTTOM - SAME AREA FOLLOWING CLOSURE OF DRAFT HOOD RELIEF OPENINGS AND MOUNTING OF DOUBLE ACTING BAROMETRIC DAMPERS





TESTING STATION AT FIELD CONTROLS CO., LABORATORY FACILITY.

TOP LEFT - TEST OF ATMOSPHERIC HOT WATER BOILER
TOP RIGHT - TEST OF FAN ASSISTED BURNER EQUIPPED HOT WATER BOILER
RIGHT - VIEW OF TEST ENCLOSURE AND SOME OF THE INSTRUMENTATION

CONCLUSION

Testing herein described indicates a trend toward improved gas appliance combustion efficiency and reduction in carbon monoxide emissions when original equipment draft hoods were replaced by double acting barometric dampers. Indications are that use of barometric dampers for gas appliance designs is a viable alternative for the traditional draft hood. Use of barometric dampers resulted in improved performance for appliances tested for all conditions with the exception of down draft conditions operation. Field testing also verified that for some of the units the addition of double acting dampers resulted in acceptable appliance performance (for CO levels under ANSI Standards) when the same appliance was operating at failure level when utilizing the original draft hoods. In order to maximize benefits of these changes, all conversion work should be conducted under the direct supervision of qualified staff.

Report Prepared By

LASZLO J. SZABOLCS
Project Engineer
A.G.A.L.
Cleveland, Ohio

Date 11/4/93

Report Reviewed By

JOHN P. GORMAN
Project Manager
A.G.A.L.
Cleveland, Ohio

Date 11/4/93

RPT. #FT-C-07-93
JOB # 23792.3
CUST # 1817

APPLICATION FOR FIELD TEST
to
American Gas Association Laboratories

Name of Applicant: The Field Controls Company (Organization)

Address of Applicant: 2308 Airport Road, Kingston, NC 28501 (Street and No., City, State, Zip)

Product Model No. and Type: Combustion Analysis Comparison, Barometric Dampers/Draft Hoods

Manufacturer: Applicant

Location of Product: Field Installed Units, Northern Ohio

TO THE AMERICAN GAS ASSOCIATION:
The above applicant applies for test work to be performed on the designated product as located or installed. The information provided in the field test report is intended only to assist code enforcing authorities and others involved in judging acceptance of the product.

GENERAL CONDITIONS

1. Test work will be related to recognized standards when applicable.
2. Applicant must provide personnel for initial start up, explanation of sequence of operation and safety features and any other work necessary during the test of the product(s).
3. The product(s) shall be installed and ready for testing under actual operation.
4. Applicant shall furnish drawings of the product(s) if requested; otherwise, the Laboratories will produce drawings to adequately describe construction of tested product(s).
5. An estimated cost for the field test work will be given to applicant, who shall pay this fee before any services are provided. Should costs exceed the initial estimate, applicant agrees to pay the additional costs immediately upon receipt of invoice.
6. The test report, or detailed results of the tests will not be divulged except with the mutual consent of the applicant.

TEST REPORT

1. Upon completion of test work and full payment, the Laboratories shall provide a test report to applicant or his designee.
2. The report shall apply only to product(s) tested, and generally only to one location or installation.
3. Applicant agrees that the field test report, if published or distributed, can only be issued as a complete entity and that no abstracts or abbreviations of the report can be made. The field test report cannot be used for or in any way proffered as evidence of certification, product endorsement or approval.

LIABILITY

1. Applicant shall indemnify and hold harmless the American Gas Association and its members, officers, directors, employees, agents and representatives from liability and for any and all claims of loss, damage or injury, of any nature whatsoever, arising out of or connected with the test work. This provision includes, but is not limited to claims, loss, damage or injury occasioned by sole simple or gross negligence of the American Gas Association and is to be construed broadly.
2. Laboratories' employees while at facilities to perform test work and inspection, agree to comply with all applicable rules and regulations known to them. Applicant shall not be liable for any loss or injury to Laboratories' property or employees sustained while on premises to conduct test work.

For the Applicant

Steve Cuzzort
(Signature)

Steve Cuzzort VP Eng
(Name printed and Title)

For A.G.A. Laboratories

R. J. Schulte
Richard J. Schulte, vice president, A.G.A. Laboratories

MAR 0 8 1993
(Dated)