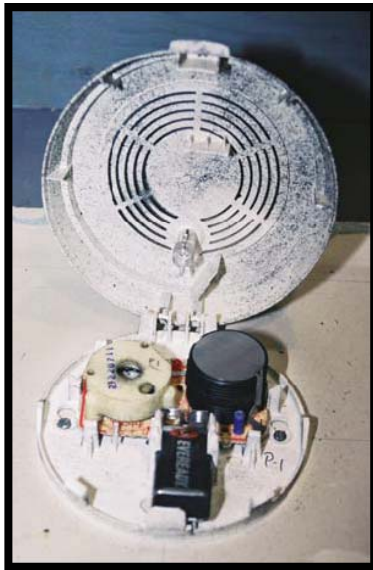


A FIRE ANALYSIS TOOL REVISITED

ACOUSTIC SOOT AGGLOMERATION IN RESIDENTIAL SMOKE ALARMS



Patrick M. Kennedy, CFEI, CFPS
Kathryn C. Kennedy, CFEI
Gregory E. Gorbett, CFEI

August, 2003
July, 2004

Investigations Institute
857 Tallevast Road
Sarasota, FL 34243
Telephone: 941-351-6409
Facsimile: 941-351-5849

Interflam 2004
10th International Engineering
Conference
Edinburgh, Scotland
July 4-7, 2004

A FIRE ANALYSIS TOOL - REVISITED ACOUSTIC SOOT AGGLOMERATION IN RESIDENTIAL SMOKE ALARMS

**PATRICK M. KENNEDY, CFEI, CFPS
KATHRYN C. KENNEDY, CFEI
GREGORY E. GORBETT, CFEI**

**John A. Kennedy & Associates, Inc.
Fire and Explosion Analysis Experts
857 Tallevast Road
Sarasota, Florida 34243**

Abstract

Introduction

Single Station Residential Smoke Alarms

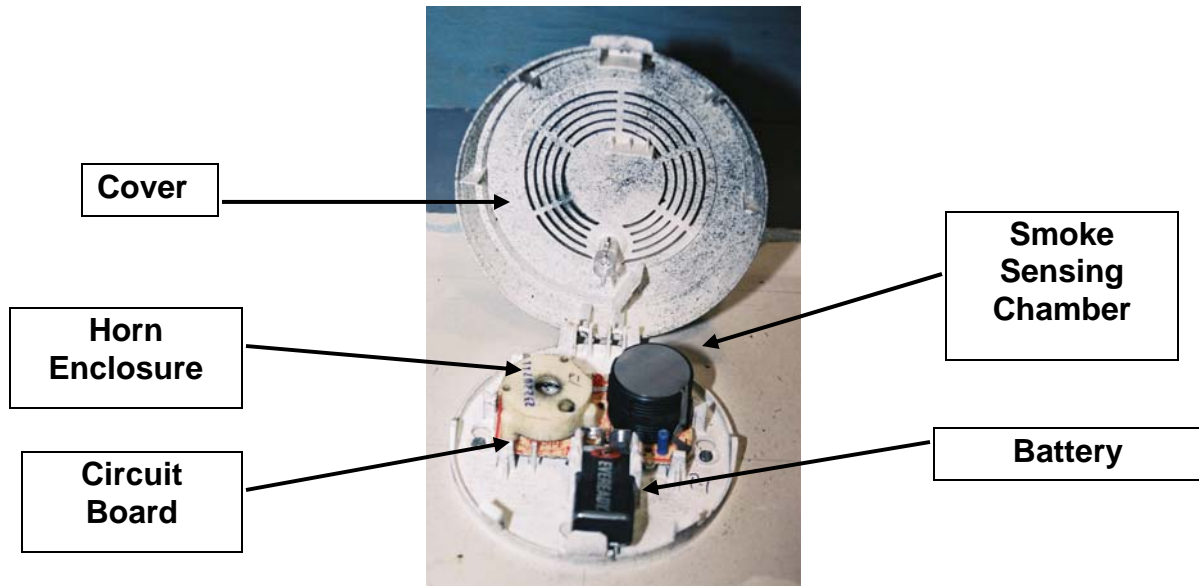


Figure 1 – Typical smoke alarm components

±

±
±



Background in Previous Research

et al

Chladni Figures

et al

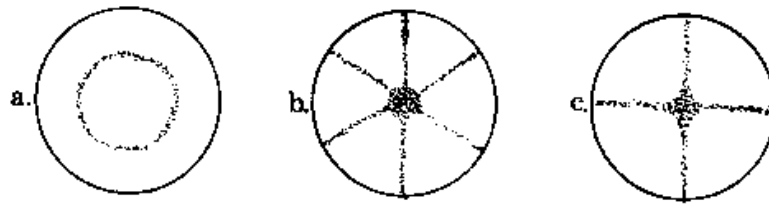


Figure 2 - Examples of Circumferential (circular) and radial Chladni figures

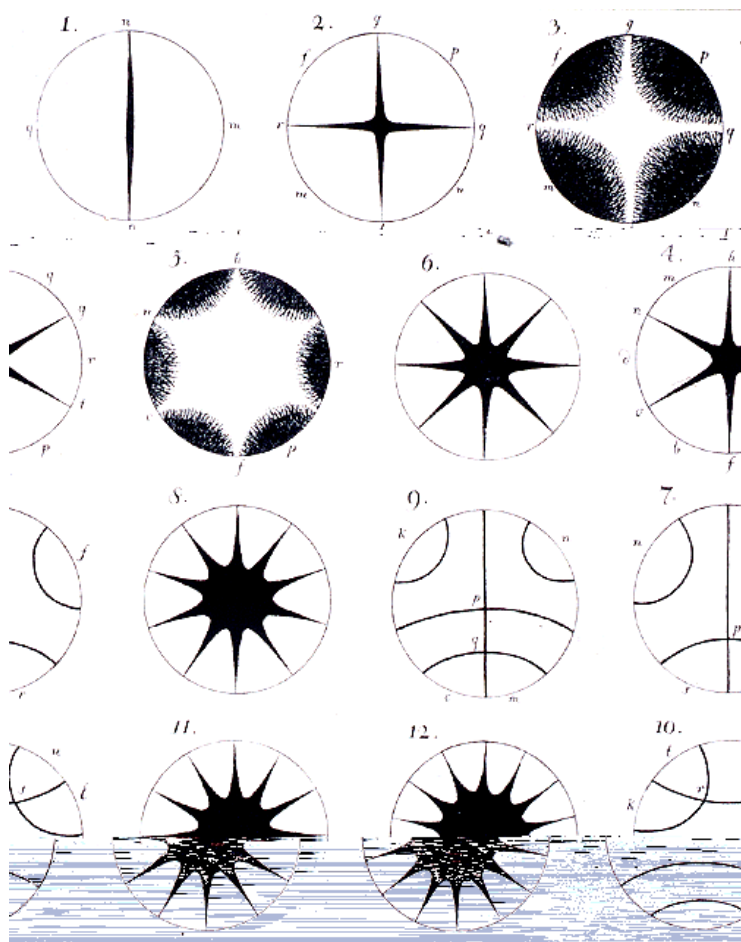


Figure 3 – Additional Chladni Figures
(from Chladni's original text).^{11,12}

Soot Deposition and Acoustic Soot Agglomeration *et al*

et al

et al

Purpose of Kennedy *et al* Testing/Research

et al

μ

≧

et al

et al

et al

et al

Research Testing Considerations

et al

Reproducibility of Testing Results

Reduction in Test Variables

Control of Test Conditions

Increased Database Size

et al'

et al

et al

et al

et al

Data Collection

et al

≡

et al

et al

Exploring Pattern Persistence

o

o

Test Procedures

Equipment

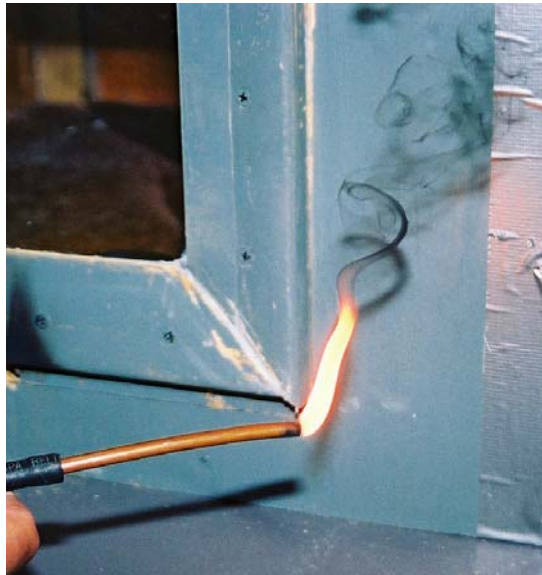


Figure 4 – Smoke Source, 2" laminar MAPP Gas flame

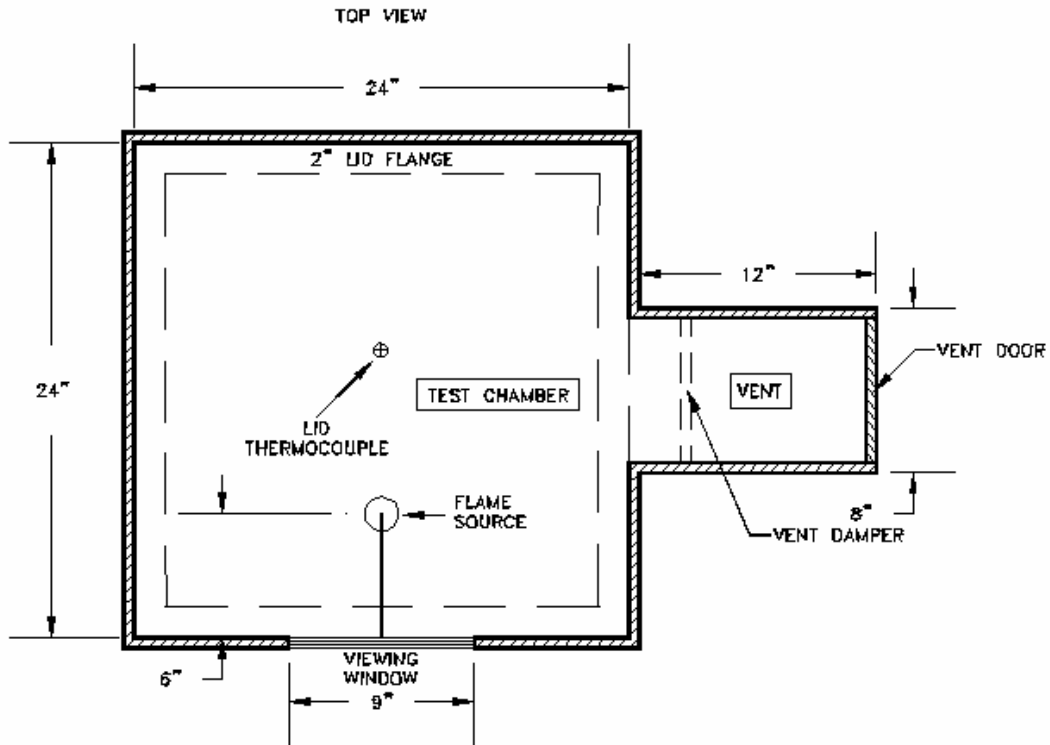


Figure 5 - Top View Drawing of Smoke Test Chamber

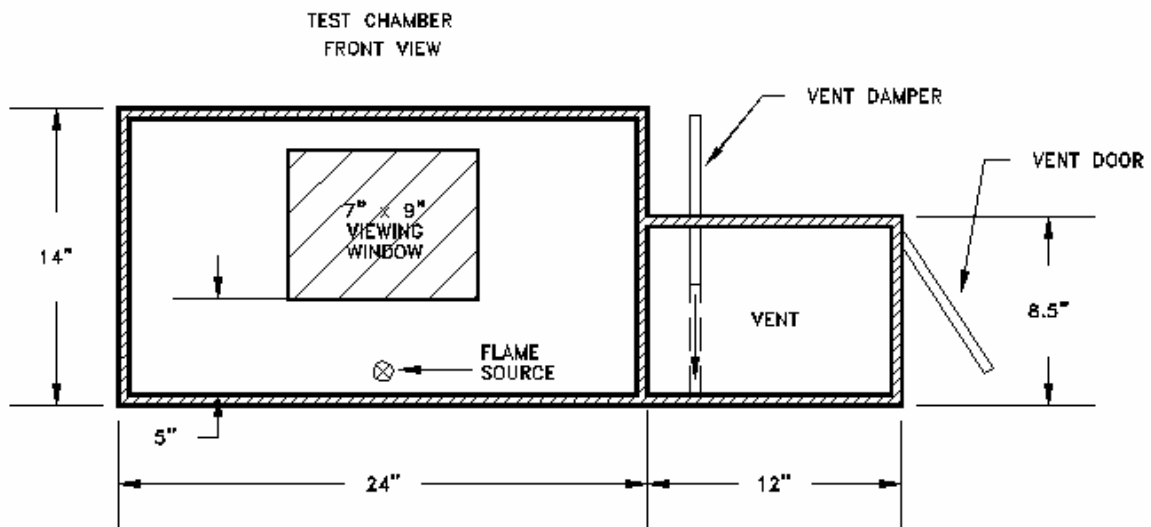


Figure 6 - Front View Drawing of Smoke Test Chamber

Protocol

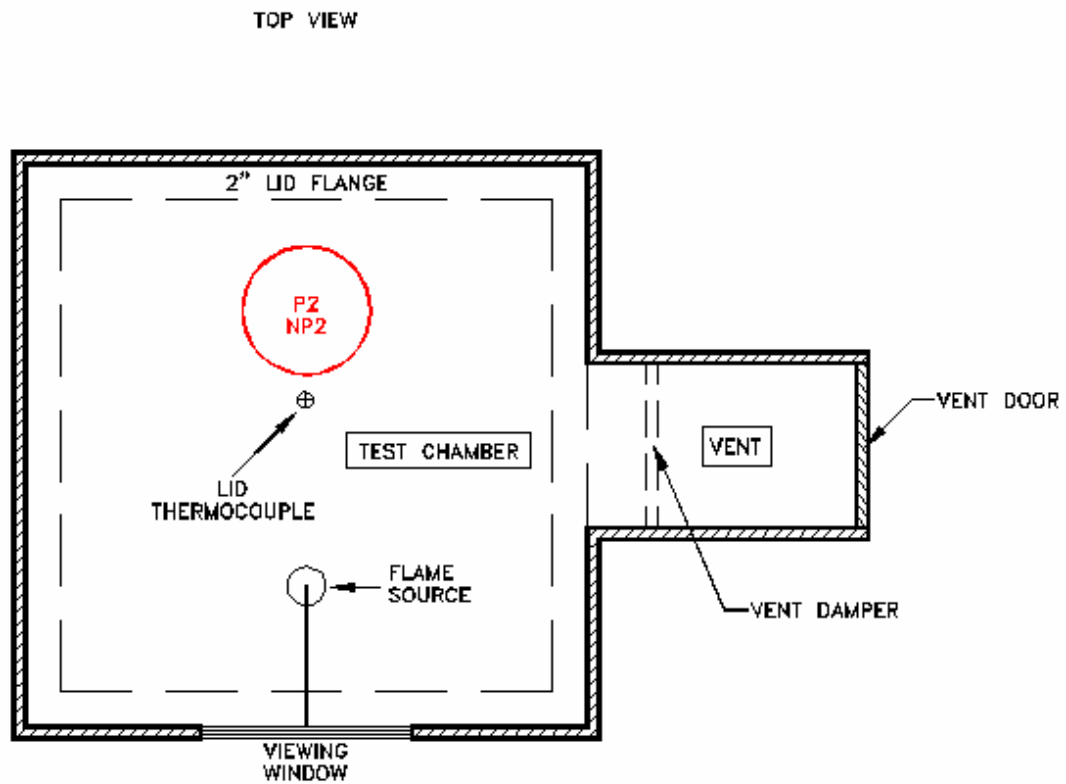


Figure 7 – Top View of Smoke Test Chamber displaying Smoke Alarm Placement

Discussion

Chladni Figures on Horn Enclosures

al *et al* *et al* *et al* *et*
et al

Sympathetic Vibrations

Patterns Persistence

○ ○

Evaluation of Combined Data

et al *et al*

et al
et al

et al

et al

et al *et al*

et al *et al*
et al

et al

et al *et al*

Findings

Acoustic Soot Agglomeration



Figures 10 a. and b. – Acoustic Soot Agglomeration around the sound exit grillwork of a Kidde Smoke Alarm



Figure 11 – Non-powered Kidde Smoke Alarm without Acoustic Soot Agglomeration on the sound exit grillwork



Figures 12a. and b. - Acoustic Soot Agglomeration on the interior surface of the smoke alarm case directly over the horn compartment central sound exit opening

Chladni Figures

Sympathetic Vibrations

Patterns Persistence

○ ○



Figures 13 a. and b. – Patterns Persistence
Soot agglomeration on a horn enclosure central sound exit opening before (left)
and After (right) heating to 433° F. (223° C) for thirty minutes

Additional Research

at al

et al

END

TABLE A - WORRELL *et al* TESTS RESULTS²³

No.	Type	Powered	Activated	Macro Black Ring	Micro Black Ring
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

**TABLE B – COMPILATION OF WORRELL *et al* RESULTS FOR POWERED
DETECTORS THAT ACTIVATED**

No.	Type	Activated	Macro Black Ring	Micro Black Ring
3				
7				
9				
11				
13				
15				
17				
19				
21				

**TABLE C – COMPILATION OF WORRELL *et al* RESULTS FOR NON-POWERED
DETECTORS THAT DID NOT ACTIVATE**

No.	Type	Activated	Macro Black Ring	Micro Black Ring
2				
4				
6				
8				
10				
12				
14				
16				
18				
20				
22				
24				

TABLE D – COMPILATION OF WORRELL *et al* ANOMALOUS TEST RESULTS

No.	Type	Powered	Activated	Macro Black Ring	Micro Black Ring
1					
5					
23					
25					
26					
27					
28					
29					
30					

TABLE E - KENNEDY TEST RESULTS

			TEST	Model		
			MFG. Code	Ionization/ Powered		
			or Photo	Outer case		
			Agglomeration	Horn Case Agglomeration	Horn Disk	
			Chladni Figure			
Outer	Horn	Horn				
Case	Case	Disk				
			Yes* ⁱ _____	Yes* ⁱ _____		

TABLE F - EVALUATION of COMBINED WORRELL *et al* and KENNEDY *et al* TEST DATA

TYPES OF TESTS	WORRELL <i>et al</i> TESTS		KENNEDY <i>et al</i> TESTS		TOTAL NUMBER OF TESTS	
	Number	Percentage	Number	Percentage	Number	Percentage
Total Number Of Tests						
Powered Tests						
Non-Powered Tests						
Anomalous Tests						
Anomalous Powered Tests						
Anomalous Non-Powered Tests						
Tests with Viable Data		21/30 (70%)		22/22 (100%)	43	43/52 (83%)
Soot Agglomeration (Powered - less Anomalous Tests)		9/9 (100%)		12/12 (100%)	21	21/21 (100%)
Soot Agglomeration (Non-Powered - less Anomalous Tests)		0%		0%	0	0%

Non-Powered

BIBLIOGRAPHY

Endnotes
