

Environmental
Health &
Engineering



building performance

Identification of Problematic Drywall: Source Markers and Detection Methods

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Specific Aims

1 - **Strontium**

Determination of the precision and accuracy of strontium concentration measurements in drywall made with field portable instruments

2 - **S₈**

Determination of elemental sulfur content in catalog drywall samples and drywall samples archived from the 51-home study

3 - **Chamber Tests**

Characterization of corrosion potential of drywall samples from the CPSC inventory ('catalog samples')

4 - **Source Markers**

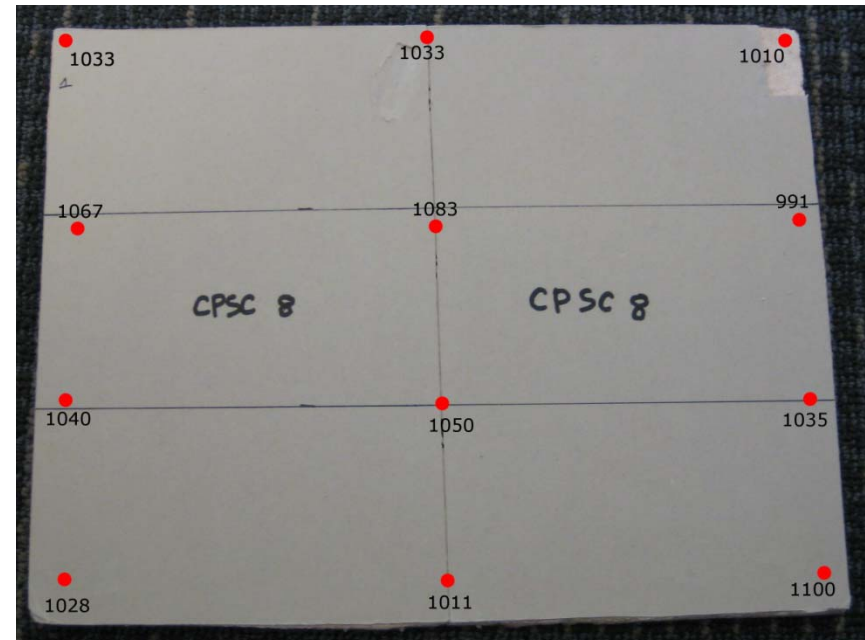
Identification of source markers of problematic drywall by comparison of source marker concentrations to both chamber-based and in-home measurements of gases and corrosion



Strontium Study Design

Strontium

- Multiple XRF analyzers
 - Innov-X, Thermo (2), Bruker
- Comparison to SRMs and lab method (ICP-AES)
- Intra-board variability



Strontium

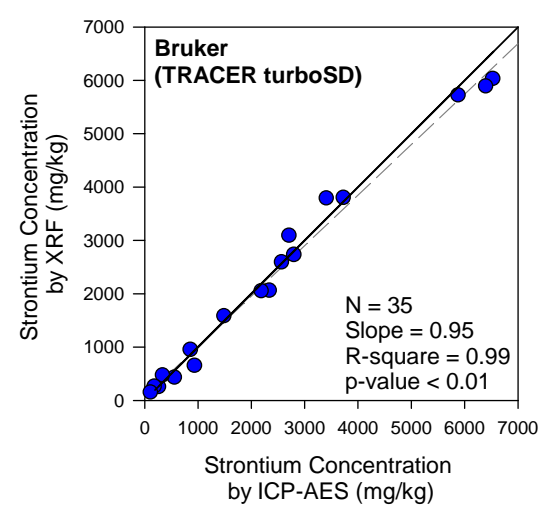
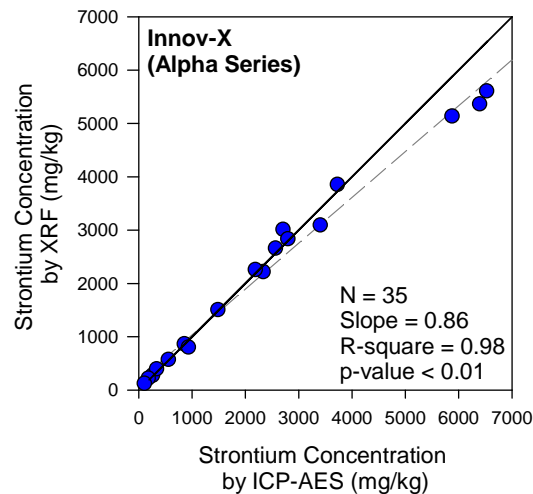
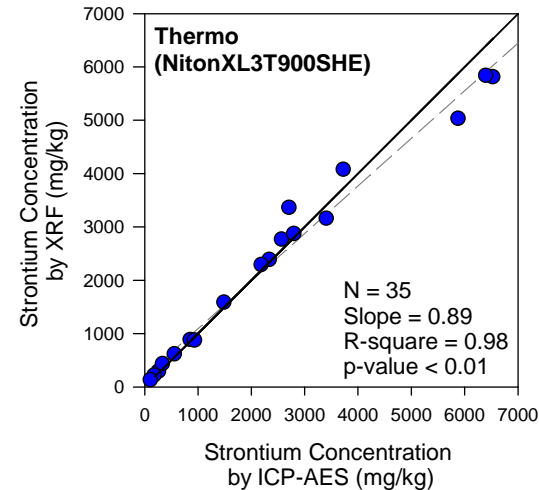
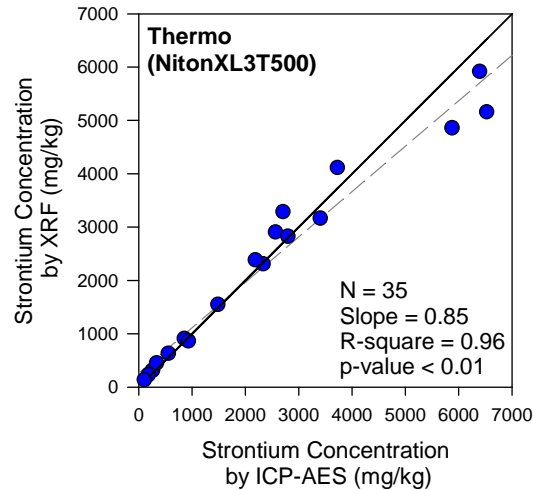
Objective 1 – Precision of XRF Analyzers

Table 3.3 Correlation Matrix of Strontium Concentrations Measured by Four Different XRF Analyzers

	Thermo (Niton XL3T500)	Thermo (Niton XL3T900SHE)	Innov-X (Alpha Series)	Bruker (TRACER turboSD)
Thermo (NitonXL3T500)	1			
Thermo (NitonXL3T900SHE)	0.998 <.0001	1		
Innov-X (Alpha Series)	0.997 <.0001	0.998 <.0001	1	
Bruker (TRACER turboSD)	0.987 <.0001	0.988 <.0001	0.990 <.0001	1

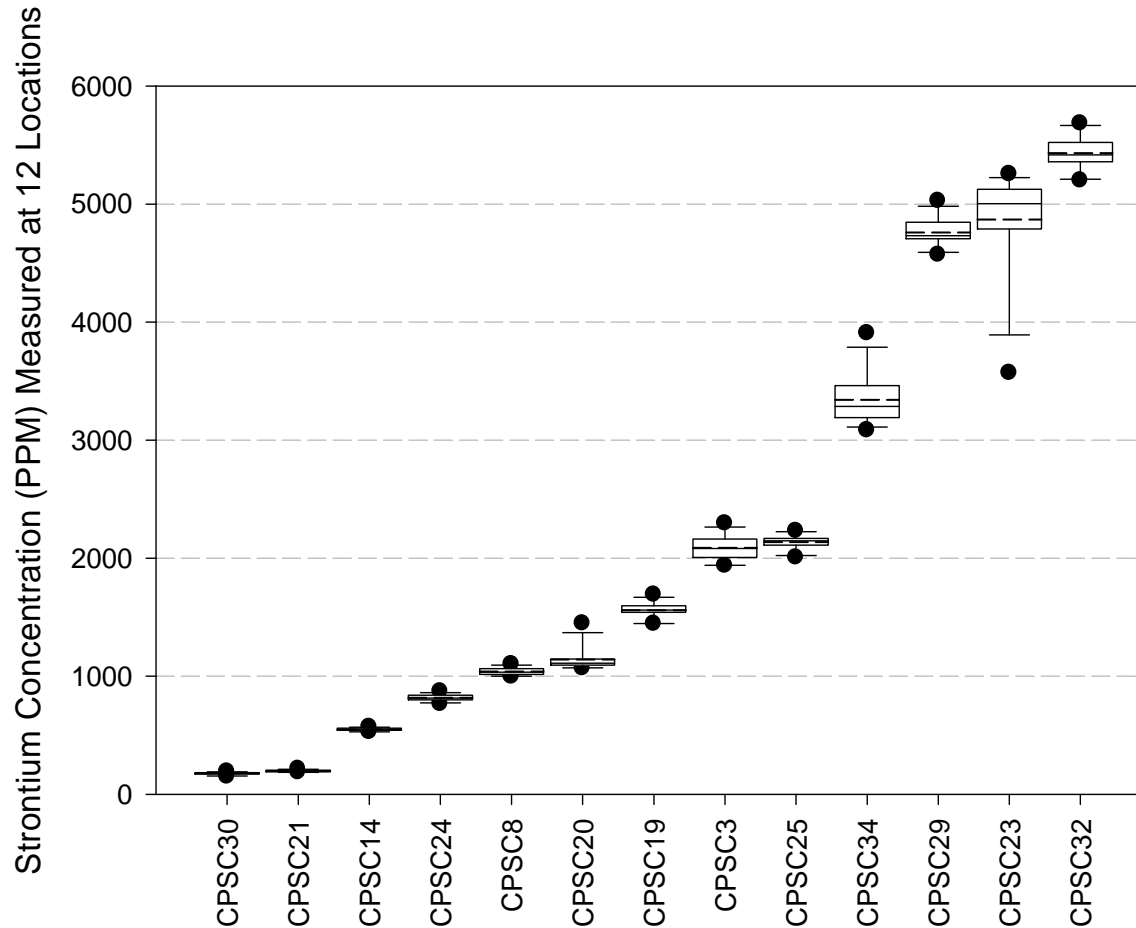
Strontium

Objective 2 – Accuracy of XRF Analyzers

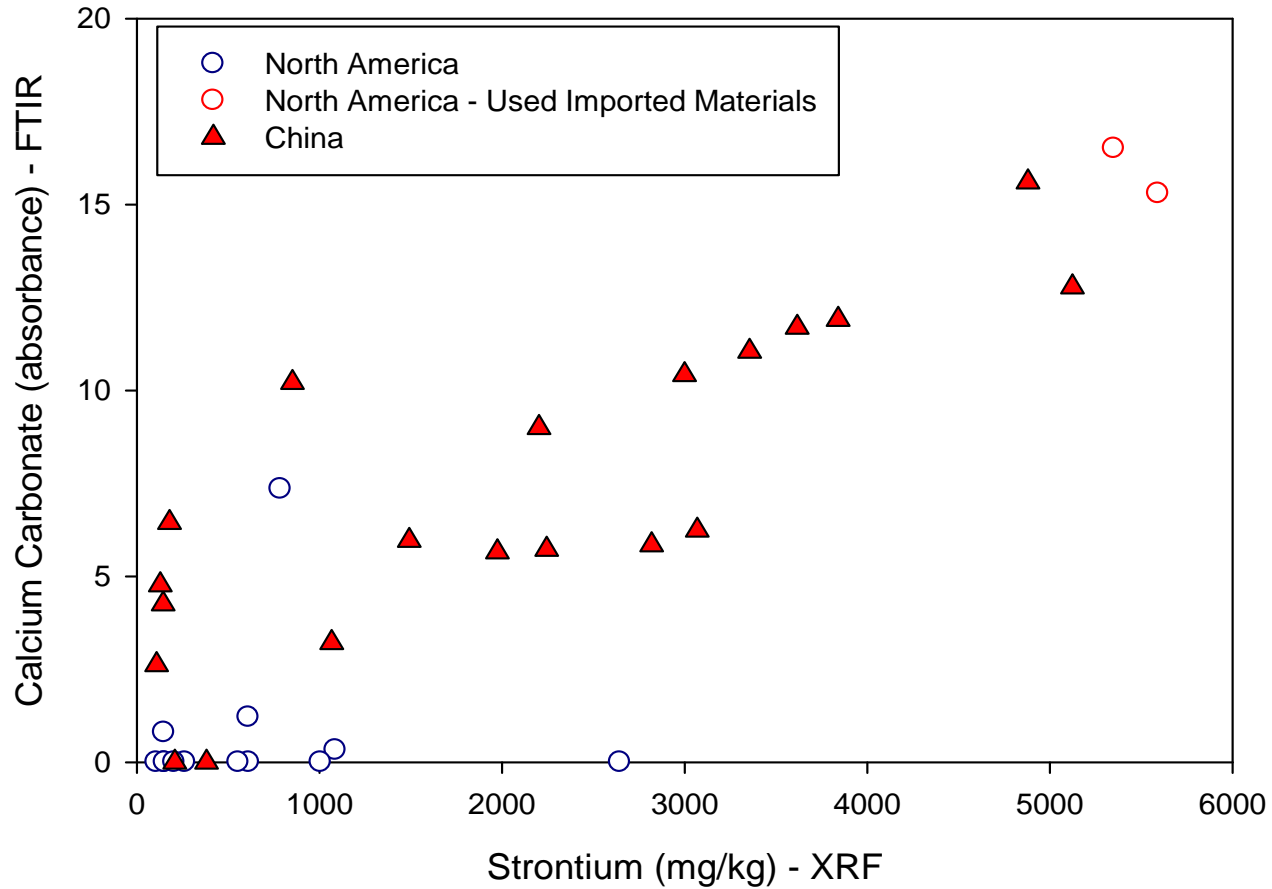


Strontium

Objective 3 – Intra-Board Variability



Strontium/Carbonate



Elemental Sulfur (S₈) Study Design

S₈

- Multiple analytic methods
 - EPA REAC 1805 Method, GC/MS, GC/ECD
- S₈ in 'catalog' samples and drywall from the 51-home study
- Intra-board variability

Table 4.1 Overview of Analytic Methods Used to Determine Orthorhombic Sulfur Concentrations	
Analytic Method	Description
EPA ERT/REAC SOP 1805	<ul style="list-style-type: none"> • Soxhlet extraction (dichloromethane:acetone) • GC/MS
GC/MS (toluene extraction)	<ul style="list-style-type: none"> • Solvent extraction (toluene) • GC/MS
GC/ECD	<ul style="list-style-type: none"> • Solvent extraction (toluene) • GC/ECD
EPA	U.S. Environmental Protection Agency
ERT/REAC	Environmental Response Team Response Engineering and Analytical Contract
SOP	standard operating procedure
GC/MS	gas chromatography mass spectrometry
GC/ECD	gas chromatography electron capture detector



Elemental Sulfur (S₈)

Objective 1 – Method Comparison

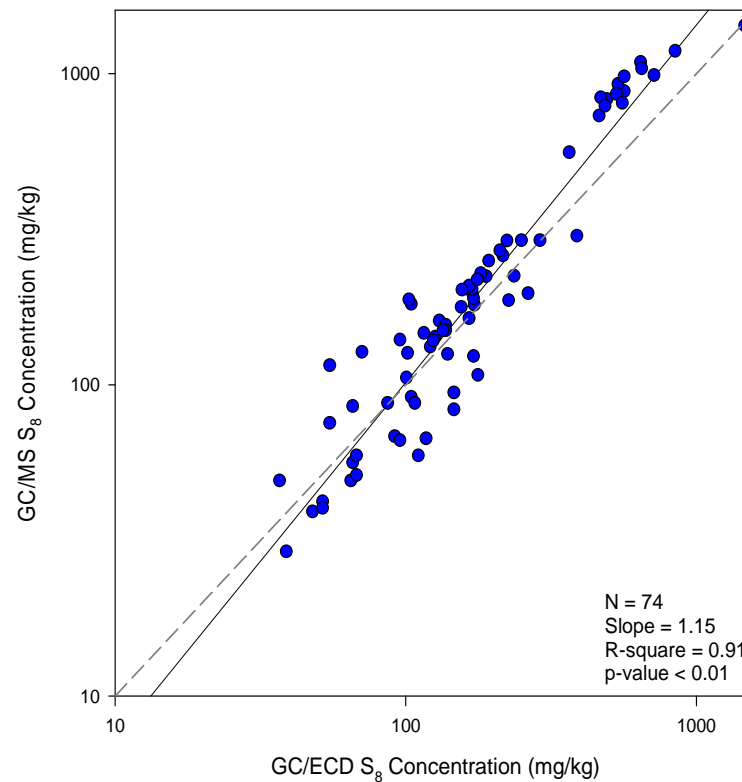
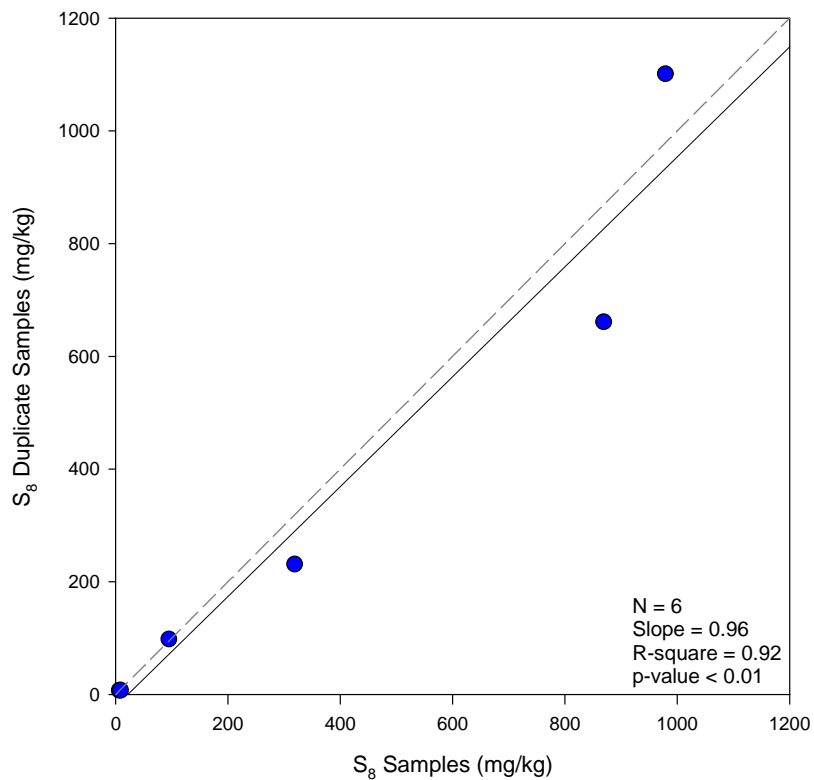
Table 4.3 Comparison of Orthorhombic Sulfur Concentrations (mg/kg) Measured Using Three Different Methods

Catalog ID	REAC SOP 1805	GC/MS (toluene extraction)	GC/ECD
CPSC1	ND	< 5	< 5
CPSC3	2.3	79	91
CPSC4	ND	< 5	< 5
CPSC5	ND	< 5	< 5
CPSC10	4.4	6	7.7
CPSC17	ND	< 5	< 5
CPSC19	ND	< 5	< 5
CPSC22	ND	< 5	< 5
CPSC23	ND	< 5	< 5
CPSC24	ND	< 5	< 5
CPSC26	ND	< 5	< 5
CPSC34	650	610	870
CPSC35	64	1,000	1,200



Elemental Sulfur (S_8)

Objective 2 – Accuracy/Precision



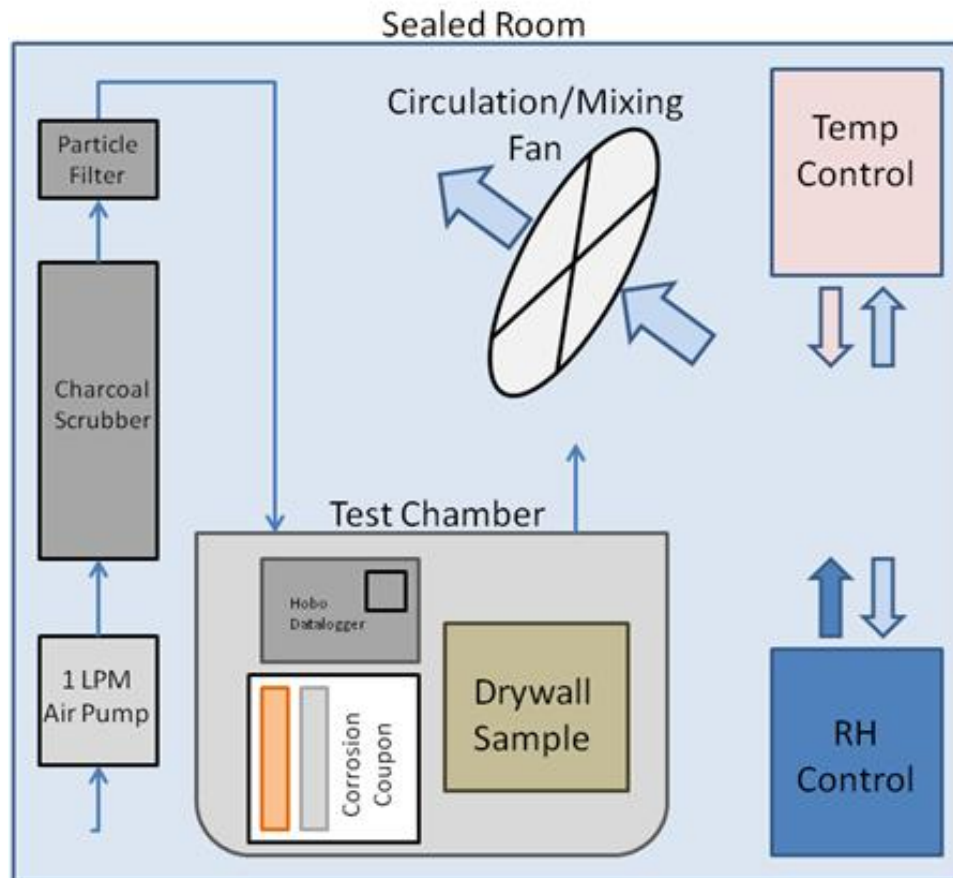
Elemental Sulfur (S₈)

Objective 3 – Intra-Board Variability

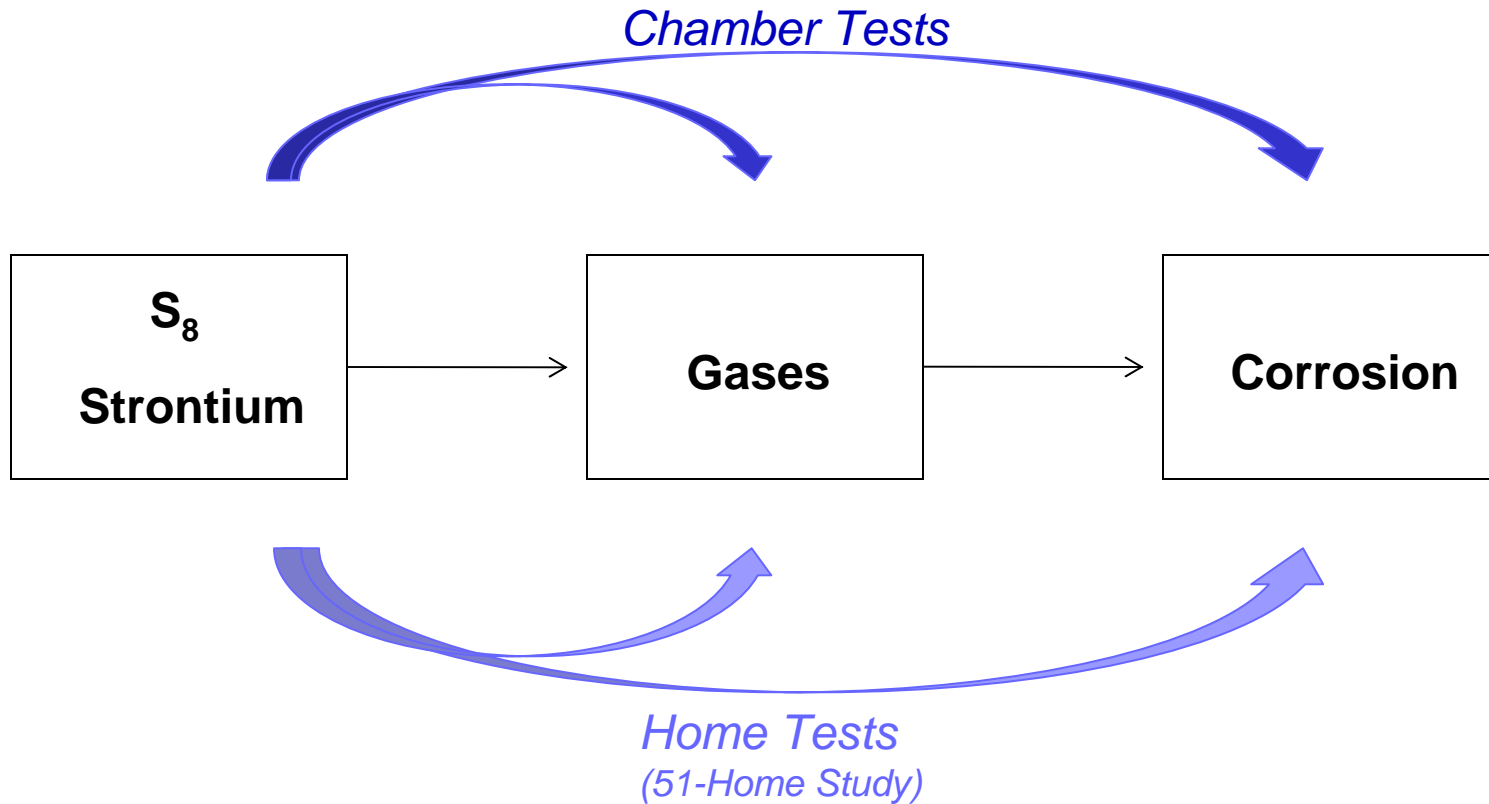
Table 4.4 Orthorhombic Sulfur Concentrations (mg/kg) at Multiple Locations Per Board

Sample ID	Sample Number											
	1	2	3	4	5	6	7	8	9	10	11	12
CPSC3	130	130	110	110	120	120	100	110	140	130	150	130
CPSC14	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
CPSC32	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
CPSC34	870	700	740	750	700							
CPSC35	690	980	1200	980	870							
CPSC10	9.9	7.9	7.7									
CPSC15	99	96	110									
CPSC25	<5	<5	<5									
mg/kg	milligrams per kilogram											

Chamber Testing Study Design

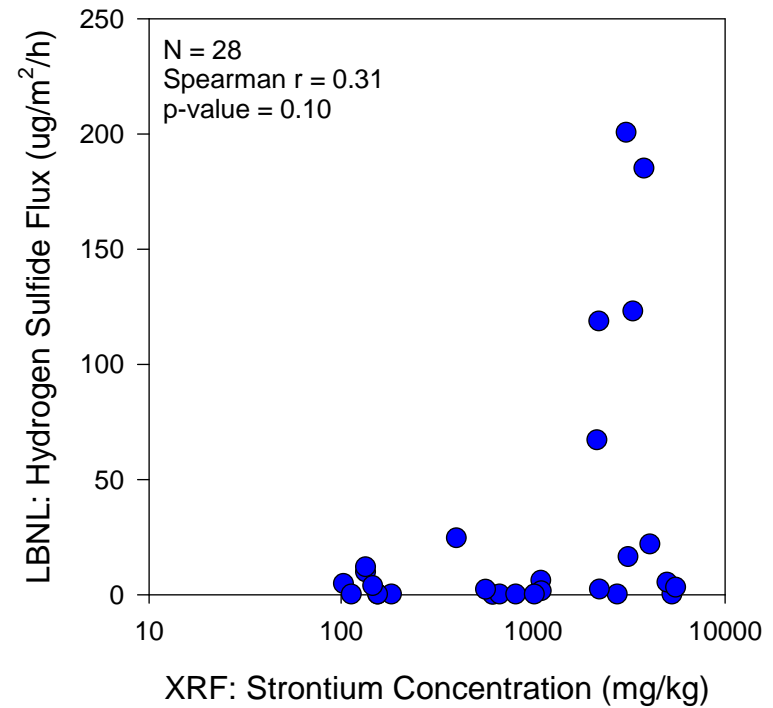
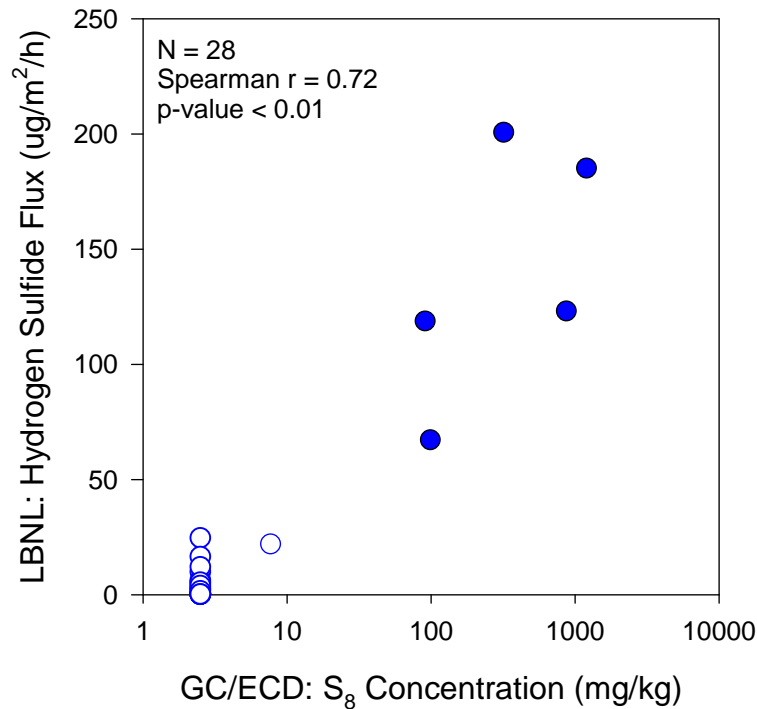


Markers v. Effect Study Design



Markers v. Effect

1a – Gases (Chamber)



Markers v. Effect

1b – Gases (51-Home Study)

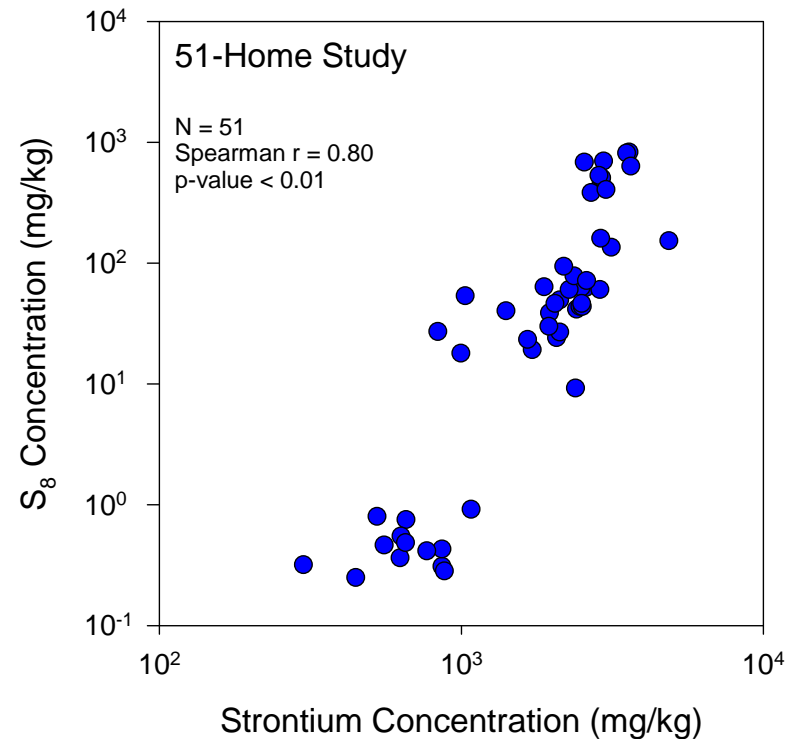
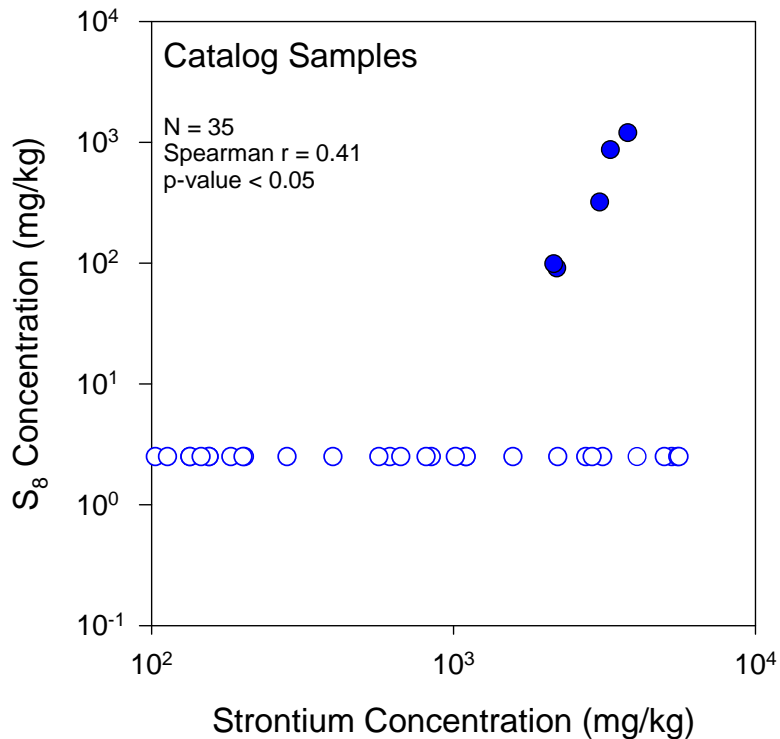
Table 6.2 Regression Model Results Showing Predictors of House Average Hydrogen Sulfide Concentrations (Natural log-transformed) in Indoor Air

Parameter	Estimate	Standard Error	p-value
Intercept	-6.28	1.20	<0.001
Strontium (natural log)	0.32	0.13	0.01
Dew Point	0.05	0.02	<0.01
Outdoor Hydrogen Sulfide (H ₂ S)	0.18	0.11	0.10

Model R²=0.38

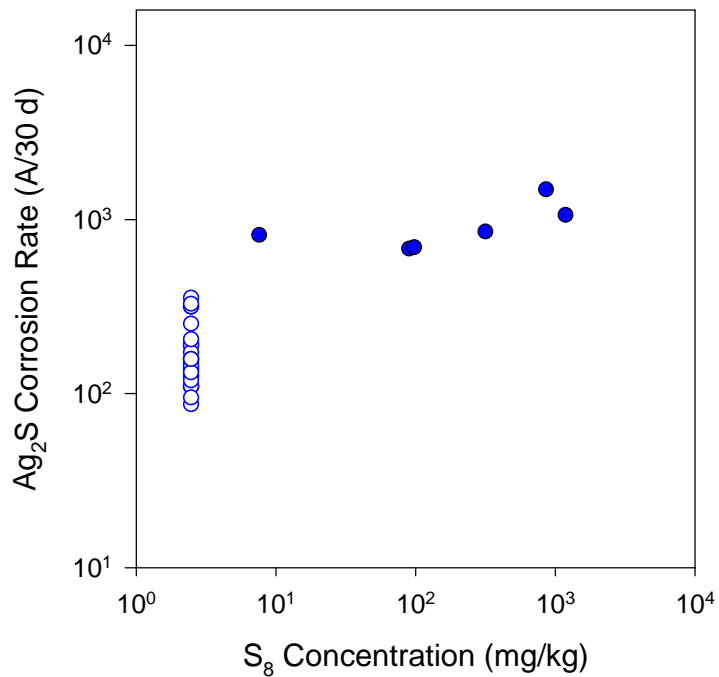
Markers v. Effect

Comparison of S_8 and Strontium



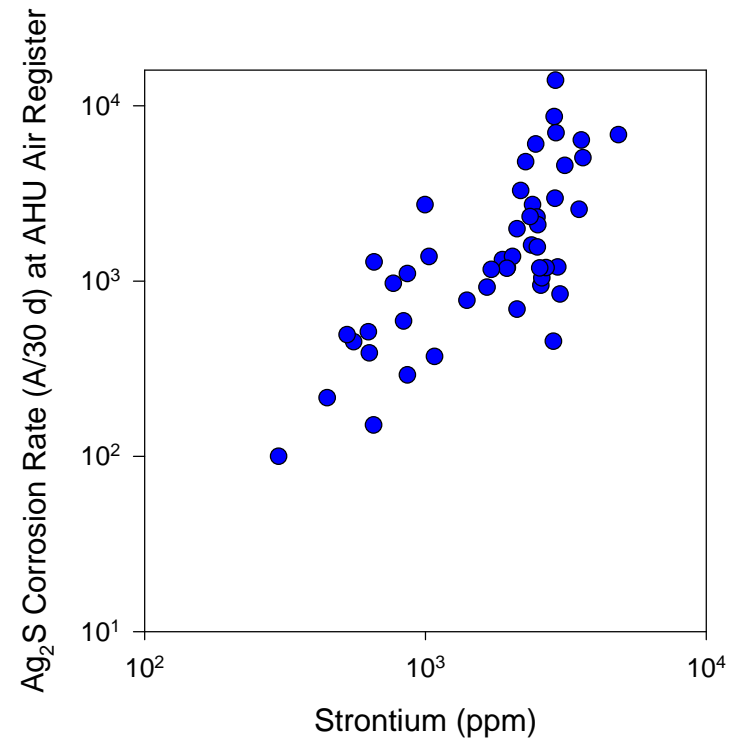
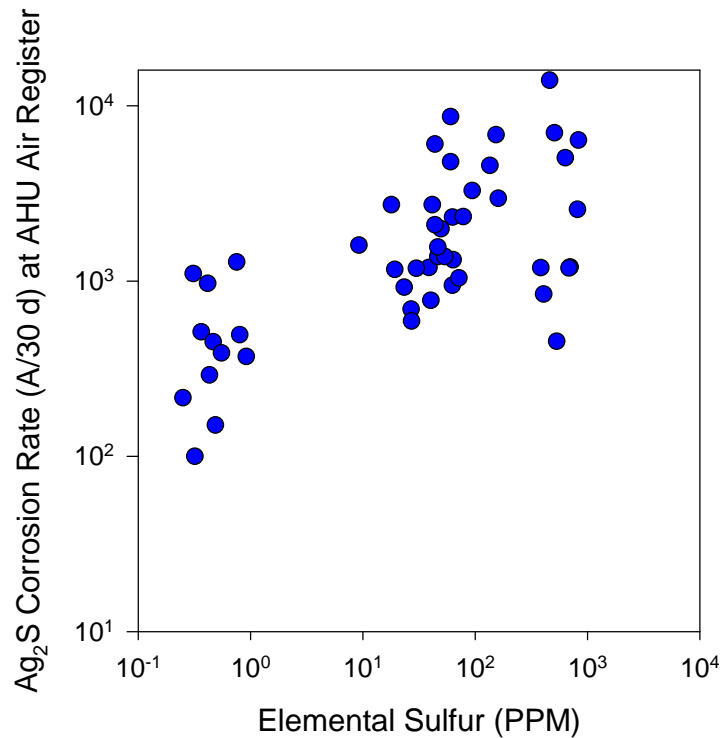
Markers v. Effect

2a – Corrosion (Chamber)



Markers v. Effect

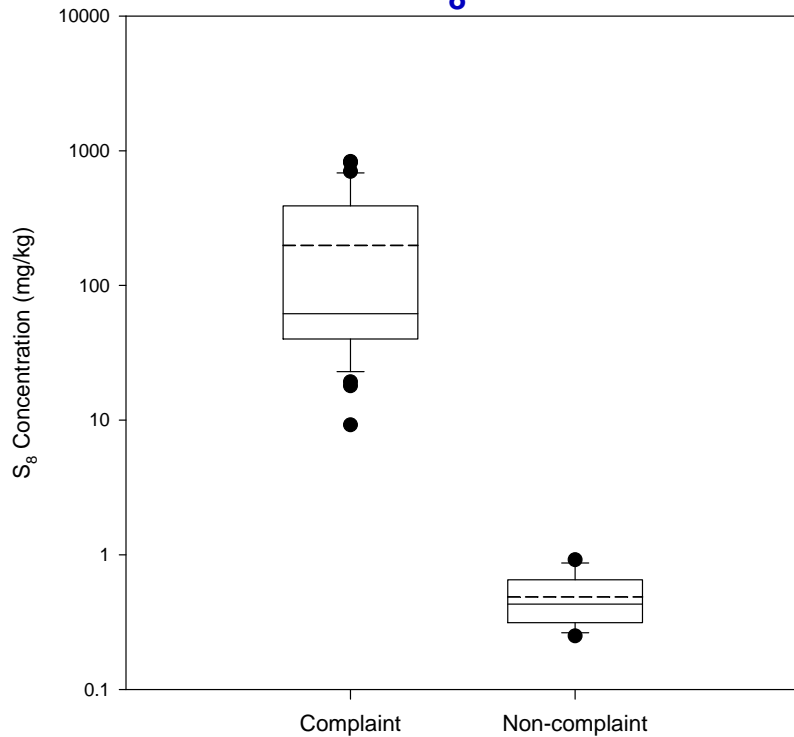
2b – Corrosion (51-Home Study)



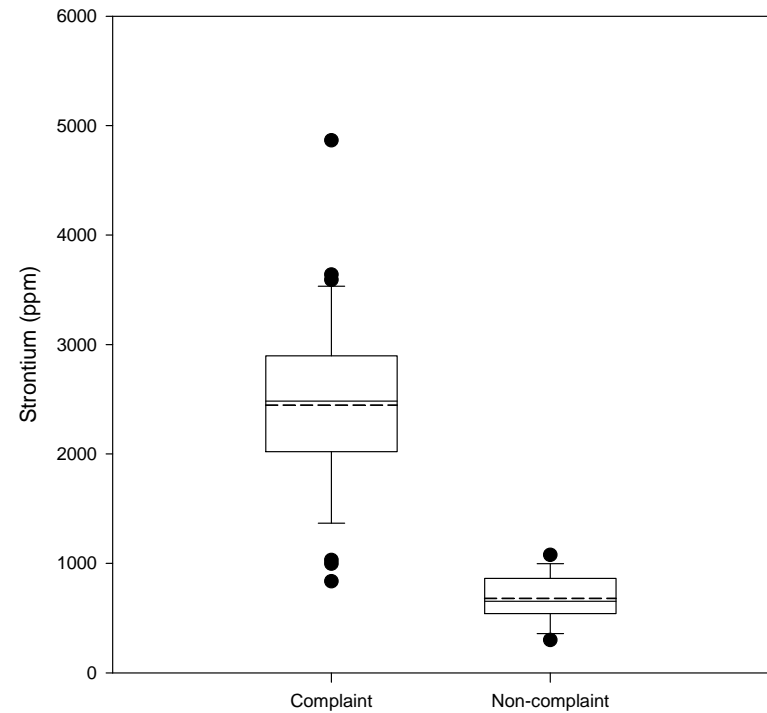
Source Markers

51-Home Study

S₈



Strontium



Summary and Conclusions

- **Strontium is a useful, but non-specific marker of problematic drywall when used in isolation**
- **Analysis of strontium in drywall samples can be reliably performed using XRF**
- **Orthorhombic sulfur (S_8) is a sensitive and specific marker of problematic drywall**
- **Orthorhombic sulfur (S_8) was not detected in any drywall samples from the non-complaint homes in the 51-home study**
- **Orthorhombic sulfur (S_8) determined using two toluene-based extraction methods showed strong agreement**
- **Orthorhombic sulfur (S_8) and strontium both exhibited low intra-board variability**



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