# Assessment and Remediation of Corrosive Drywall

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**SUMMARY**

Chinese drywall manufactured from gypsum intermingled with naturally-occurring sulfur has been used extensively in the construction of U.S. homes. When exposed to heat and moisture, this product emits a mixture of sulfide gasses associated with odor, electrical and mechanical system damage, and health concerns. An assessment protocol is presented for classifying homes by drywall status. In most cases, an inspection is sufficient to determine whether CDW is present. Blackening of air conditioning coils, uninsulated ground wires, and accessible piping can be identified visually. Specific CDW locations can be delineated by scanning the walls with portable x-ray fluorescence (XRF) measuring strontium content. Laboratory analysis for elemental sulfur confirms that drywall is corrosive. Remediation based on CDW removal must also eliminate demolition dust and residual odor to be effective. Air quality can be evaluated by air corrosivity measurement supplemented by systematic odor evaluation.

**IMPLICATIONS**

Corrosive drywall is a recent IAQ issue, producing significant corrosion and odor problems. It is also linked to irritation-type symptoms in sensitive occupants. The complexity of this issue presents unique challenges to field practitioners tasked with home evaluation and to remediation contractors. Guidance is presented based on currently available information.

**KEY WORDS**

residential, sulfides, irritation, corrosion, building evaluation

**INTRODUCTION**

Corrosive drywall (defined as contaminated gypsum board that emits sulfides in elevated concentrations) was imported into the United States from China starting around 2001 and has been installed in thousands of homes (CPSC, 2009). When relative humidity is elevated, corrosive drywall (CDW) emits a variable mixture of inorganic and organo-sulfides in the low parts per billion (ppb) range (Burdack-Freitag, 2009). These compounds include highly corrosive agents and contaminants with very low odor thresholds (CPSC, 2009). Although an underlying mechanism has not been confirmed, one hypothesis is that elemental sulfur and carbonaceous material naturally intermingled with the gypsum ore react during drywall manufacturing (wet process at high temperatures) (Burdack-Freitag, 2009).

Some occupants attribute a variety of symptoms to CDW in their homes. Preliminary research suggests that occupants pre-disposed to mucous membrane irritation may experience short-term irritation effects associated with CDW emissions (Manis, 2009). Sulfidation (sulfide corrosion) is frequently found in CDW homes and has been associated with the failure of air-conditioning coils and damage to other electrical and mechanical components (CPSC, 2009). A unique odor is often detectable in CDW homes resembling a burnt match.

A variety of procedures and criteria are used by field practitioners to verify the presence of CDW. While sulfide corrosion is visible as a unique, soot-like coating (blackening) on exposed wiring and piping, sewer gas or water containing hydrogen sulfide may cause the same effect. Where CDW is localized within the structure, visible blackening of susceptible wiring and piping is generally limited to surfaces within several feet of corrosive panels. Heaviest blackening is generally observed on coils in air conditioning units, where CDW emissions in return air mix with humid air.

This paper presents a summary of general principles for CDW assessment and emissions based on currently available information. While only single-family homes are addressed, CDW has also been identified in multi-family residences and some commercial buildings. With respect to remediation, this paper focuses on decontamination measures. Exposure reduction and repair of corrosion damage are outside the scope.

## METHODOLOGY

This study included a review of the scientific literature, interviews with homeowners, field practitioners, and remediation contractors and inspections of homes with CDW. A protocol for CDW assessment and remediation was developed from this information.

## RESULTS

### Assessment of Homes for CDW

The basic goal of assessment is to determine whether CDW is present. CDW can generally be ruled out where drywall was installed before 2001. A simple screening may be sufficient to classify many homes, with negative findings establishing that CDW is unlikely to be present. However, a conclusive negative finding should be based on more detailed investigation. If an initial screening establishes that CDW is widespread (i.e., present in most rooms), further investigation is generally not needed. If CDW appears to be localized, further investigation is needed to proceed with selective removal.

*Initial Screening*

**Step One: Review of site documentation**. Dates of drywall installation and product documentation are often available. Construction history may also localize areas where CDW was used.

**Step Two: Occupant Interview**. Observed conditions, including any history of electrical or mechanical failures, should be noted.

**Step Three: Odor Evaluation**. Detection of burnt match-type odor is suggestive of CDW. This should be distinguished from “rotten-egg” odor, which indicates the presence of other hydrogen sulfide sources such as sewer gas or water with naturally-occurring hydrogen sulfide. Although these latter odors may be intermittent sources can generally be identified by inspection and occupant interviews.

**Step Four: Corrosion Inspection**. Evaluation of electrical system condition focuses on exposed metal components such as uninsulated ground wires and wire tips at connections. These can be observed by opening utility outlet covers, light fixtures, and breaker boxes. Mechanical inspection focuses on metal plumbing fixtures, and uninsulated copper piping. Air conditioning units should be opened, looking for blackening of the coils. The inspection should also include susceptible metal contents (i.e., silver). The initial screening is limited to inspection of representative locations. Where blackening is observed at the majority of these sites, CDW can be assumed to be widespread for purposes of remediation planning. Because blackening can also be caused by strong sources of naturally-occurring hydrogen sulfide, testing of the drywall may be needed to confirm the presence of CDW where other sulfide sources are suspected.

**Detailed Investigation**

After the above screening is completed, additional evaluation is needed to: (1) confirm a negative finding where drywall was installed after the year 2000; (2) locate corrosive panels; (3) delineate areas free of CDW; or (4) identify source(s) of surface blackening where sewer gas or water containing hydrogen sulfide are suspected.

Detailed CDW investigation may include one or more of the following:

- Comprehensive corrosion inspection (all accessible locations);
- Scanning of drywall by a hand-held XRF instrument to determine strontium content;
- XRF scanning of discolored metal surfaces to confirm the presence of sulfur;
- Analysis of bulk drywall samples for elemental sulfur content, sulfide emissions (chamber test), or copper corrosion (jar test);
- "Pin Tests" (insert small copper nails into drywall and observe for corrosion)
- Documentation of accessible drywall labels;
- Monitoring for air corrosivity; and/or
- Air monitoring based on measurement of sulfur deposition on a copper probe.

<u>Corrosion Inspection</u>. All accessible sites should be evaluated following the procedure in Step Four (see above).

<u>X-Ray Fluorescence</u>. Scanning materials with XRF is used to measure metal content. CDW is generally associated with elevated concentrations of strontium, although that element does not contribute to CDW emissions. Hand-held XRF monitors are available for field use and can be used to scan accessible drywall, although paint and wall coverings may reduce or increase the drywall strontium reading (Kominsky, 2010). Measurements can be adjusted by the ratio of an uncoated drywall reading (i.e., exposed edge) divided by a reading of the coated drywall. Subsequent readings of drywall with the same surface treatment are multiplied by this value. Readings should not be taken at drywall panel edges with joint compound. Where drywall is inaccessible (i.e., covered by attached cabinetry) similar strontium readings to those around the perimeter can be assumed unless corrosion (or lack thereof) in the area suggests the presence of a different drywall product.

CDW imported from China has generally been found to have a strontium content exceeding 1800 parts per million (ppm). A few non-CDW drywall products also have elevated strontium content (Babich, 2010). False positive conclusions can be avoided by laboratory analysis of high-strontium drywall in areas without blackening. On rare occasions, CDW can have a low strontium content. Where blackening is observed near low-strontium drywall, this can be resolved by bulk analysis.

Laboratory Analysis. CDW emissions are consistently associated with the presence of an allotrope of elemental sulfur in drywall (orthorhombic cyclooctasulfur). Bulk drywall samples can be analyzed for this parameter by gas chromatography/electron capture detection. Sulfide emissions from CDW can be detected in a static chamber test. Another test exposes copper to a piece of CDW in a closed container, with visible blackening suggestive of CDW emissions (Tuday, 2009). False positive readings may result from emission testing of non-corrosive drywall that has become a sink for nearby CDW emissions. Where this is suspected, drywall classification should be based on elemental sulfur analysis. Although CDW can be confirmed by laboratory testing, each finding is directly applicable only to the site sampled. The result may be applied to a wider area demonstrated to have the same type of drywall (i.e., by XRF scanning).

Product Labels. Where they can be accessed, markings on installed drywall may indicate whether or not it is corrosive. Labels can be observed on unfinished drywall (i.e., in return air plenums), drywall ceilings open to the attic, unfinished areas where drywall remains open at the back, and through cut access holes. Information is available correlating product labels and other markings with corrosivity (Babich, 2010).

Air Monitoring. Chemical testing for airborne sulfide mixtures at low concentrations is not feasible. CDW emissions can be monitored by a combination of odor evaluation and air corrosivity measurement. Air corrosivity is a parameter used by clean room industries to monitor the cumulative impact of airborne contaminants (Leygraf, 2000). False negative conclusions based on air corrosivity are possible under dry conditions when CDW can temporarily stop emitting sulfides. Burnt match-type odor may still be detected at a time when air corrosivity is low. False positive conclusions based on air corrosivity are possible where sources of corrosive emissions other than CDW are present. Such interferences can be minimized by identifying and controlling non-CDW sources during the test period.

**Remediation of CDW Homes**

CDW emissions are persistent and may continue for years if not controlled. Attempts to treat the drywall in place have generally not been successful, although work is ongoing in this area. Most decontamination efforts include replacement of CDW. However, this alone does not eliminate sulfide emissions, which will continue to be released from any remaining demolition dust and odor adsorbed on remaining surfaces. Various methods are in use to eliminate demolition dust and residual off-gassing, although their efficacy has not been established.

Removal. Drywall replacement includes removal of adjacent trim for access and insulation that could trap demolition dust. Other building materials and furnishings can be retained if they are protected against damage during remediation and residual odor is resolved. Where CDW is widespread throughout the home, remediation projects generally remove all drywall. More than one drywall product is installed in many homes and non-emitting drywall is often present in CDW homes. Selective drywall replacement may be feasible where large areas are found to be free of CDW. However, leaving non-CDW in place may block access needed to control residual dust, treat secondary odor sources or repair corrosion damage.

Dust Cleanup. Elimination of demolition dust requires a systematic process. Dust spread can be minimized by relocating contents, sealing openings from the work site, covering non-drywall surfaces, gently cutting the drywall, and operating high efficiency particulate (HEPA) air scrubbers to capture airborne dust before it settles. After debris removal and rough cleaning, all surfaces should be cleaned by HEPA vacuuming followed by damp wiping. Some contractors add a final polishing step (i.e., blowing air on difficult to access surfaces, capturing dust while airborne with a HEPA vacuum and then re-cleaning the area). The cleaning process must continue until no demolition dust is visible.

Residual Odor. Volatile pollutants often adsorb to porous surfaces and continue to be released as secondary odors after removal of the primary source. This sink effect is eventually resolved after surface residues completely off-gas. Elimination of secondary odors is facilitated by airing out the structure, although that process may take from several days to several months after removal of CDW. Other odor control procedures are also used by contractors to supplement or replace the air-out process. These include surface treatment with a scavenging solution, fumigation, hydroxyl generation, and accelerated ventilation. Although some of these procedures are reported to be effective, none has been validated.

Contents. Contents and furnishings in homes with CDW may also retain odor. This can generally be resolved by removing them from affected areas, cleaning (i.e., laundering or vacuuming surfaces), and then airing out. The effectiveness of this process can be evaluated by sealing representative items with plastic. If CDW odor is detected under the plastic, contents and furnishings should be further treated before being returned.

Clearance. Efficacy has not been generally established for any CDW remediation process. Reconstruction of remediated CDW homes should thus not commence until decontamination is verified. An initial evaluation must confirm that all specified drywall and insulation has been removed and that no demolition dust is visible. A period of time is then required for air quality to stabilize. Post-remedial testing should not commence until a new equilibrium is established. This equilibrium is dependent on environmental conditions. A near worst-case condition (i.e., area closed up before evaluation with relative humidity elevated) provides the best assurance that CDW emissions have been eliminated.

The first step in air quality evaluation involves an odor panel (at least two individuals classifying odor based on initial entry into an area). If no burnt match-type odor is detected, then air corrosivity testing of representative areas can be initiated. All air corrosivity measurements must fall within the normal background range for acceptance.

## CONCLUSION

The presence of CDW in a home can be the source of significant corrosion and odor problems and may impact the health of sensitive occupants.

## RECOMMENDATIONS

1. Screening of homes for CDW should consider construction history, odor, source inspection, and spot checking for sulfide corrosion (blackening of metal surfaces).
2. More detailed investigation can include comprehensive corrosion inspection, XRF scanning, product label documentation, and laboratory analysis for elemental sulfur or sulfide emissions.
3. Remediation generally requires removal of drywall and adjacent insulation, followed by elimination of demolition dust and residual odor.
4. Where CDW is localized, selective drywall removal may be feasible.
5. Remediation should be verified by a combination of odor evaluation and air corrosivity measurement under near worst-case conditions.
6. Further research is needed for the characterization and control of CDW emissions.

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