UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF PREVENTION,
PESTICIDES AND
TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Zinc Pyrithione (Zinc Omadine®, or Zinc 2-pyridinethiol-1-oxide): Occupational and Residential Exposure Assessment for the RED Document. Chemical No. 088002. Case No. 2480. DP Barcode: D308705

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Attached is the Occupational and Residential Exposure Chapter for AD/RASSB's science assessment of Zinc Pyrithione (Zinc Omadine®) for the purpose of issuing a Reregistration Eligibility Decision (RED) document. Potential non-dietary exposures to occupational and residential handlers are addressed in this document, along with postapplication exposure from contact with zinc pyrithione-treated articles.

1.0 EXECUTIVE SUMMARY

Background

Zinc pyrithione (Zinc Omadine®, or Zinc 2-pyridinethiol-1-oxide) is used as an industrial preservative to prevent microbial deterioration and to maintain the integrity of manufacturing precursor materials and finished manufactured articles. Zinc pyrithione is a bacteriostat, fungicide, microbiocide/microbiostat registered for incorporation into food packaging adhesives (indoor food), incorporation into articles made from or coated with FDA approved food contact polymers such as food processing equipment, conveyor belts, utensils, and storage containers (indoor food), dry film preservation of architectural/industrial non-marine paints (indoor/outdoor nonfood), control of bacterial growth on laundered products (indoor nonfood), and materials preservation of adhesives, caulks, patching compounds, sealants, grouts, latex paints, coatings, dry wall, gypsum, pearlite, and plaster (indoor nonfood). Zinc pyrithione is used for the control of mildew in nonfood contact polymers and control of mildew and bacteria in styrene butadiene rubber and thermoplastic resins (e.g. carpets and other floor coverings, textiles, home furnishings, housewares, sports equipment, automotive/public transport systems, mattress liners, air ducts, etc.). Materials preservation extends to in-can preservation of clay, mineral, pigment and guar gum slurries, latex emulsions, and similar high solids aqueous media.

Zinc pyrithione is also conditionally registered as an antifoulant for incorporation as an active ingredient into boat paints used on the hulls of recreational and commercial craft to control slime and algae growth below the water line. Zinc pyrithione is incorporated into antifoulant paint formulations at maximum rates up to 50,000 ppm active ingredient (i.e., maximum incorporation into paint matrices at 5% a.i.). There are currently eleven registered products containing zinc pyrithione for antifoulant uses: two are for formulator use in manufacturing antifoulant paints, and of the other nine, one is a paint concentrate (as part of a two-component mixture), and eight are ready-to-use paints.

Residential exposures and risks from use of antifoulant paint containing zinc pyrithione are assessed in this chapter. An exposure/risk assessment for occupational exposures associated with this use pattern is not included in the current Zinc Pyrithione RED. However, the occupational use on commercial vessels will be evaluated at a later date. The registrant, Arch Chemicals, Inc. is conducting a study to assess exposures of workers performing painting of commercial vessels with antifoulant paints containing zinc pyrithione. This study is expected to be completed and submitted in 2006, and will be used to assess the conditional registrations for the antifoulant paint use. The registrant has submitted a protocol to AD that, when accepted, will allow the registrant to gather experimental data on exposures of workers performing painting of commercial vessels with zinc pyrithione antifoulant paints.

There are currently seven registered industrial end-use products containing zinc pyrithione for use as a materials preservative that are eligible for reregistration under Case 2480. They range in active ingredient concentration from 5% a.i. to 95% a.i. and are sold as powder, liquid, and aqueous dispersion (solids in liquid) formulations. The end-use products are applied during the manufacturing process of the incorporated treated articles and treated article precursor materials. Zinc Pyrithione formulations are added at maximum rates up to 5000 ppm active ingredient (i.e., incorporation into treated materials at 0.5% a.i.) using both open pouring and closed delivery systems. They are added at a point where thorough mixing takes place. For preservation of laundered fabrics/textiles, zinc pyrithione is incorporated at maximum rates of 56 ppm active ingredient (i.e., 0.005% a.i.) during the laundry sour operation. Variations in formulations, conditions of use, and desired degree of protection for the manufactured articles/substrates determines the pesticide use rates.

The resulting manufactured zinc pyrithione-treated end products which are sold or distributed are exempt from pesticide registration requirements under FIFRA if they qualify as treated articles under the “treated articles exemption” [40 CFR, Part 152.25(a)]. The "treated articles exemption" provides an exemption from FIFRA requirements for qualifying articles or substances treated with, or containing a registered pesticide if (1) the incorporated pesticide is registered for use in or on the article or substance itself, and (2) the sole purpose of the treatment is to protect the article or substance itself, not to provide additional pesticidal (antimicrobial) benefits.

Occupational and Residential Exposures

The Occupational and Residential Exposure Chapter of the Zinc Pyrithione Reregistration Eligibility Decision Document (RED) addresses potential exposures and risks to humans who may be exposed to zinc pyrithione in both “occupational” and “residential” settings. Specifically, in support of the materials preservation use patterns, this RED Chapter estimates non-dietary exposures and non-cancer risks to: primary occupational handlers (mixers, loaders, applicators) of registered zinc pyrithione pesticide product concentrates in industrial settings; and secondary occupational/residential handlers of zinc pyrithione-treated end products (e.g., paints) in residential settings. In addition, the use of zinc pyrithione as an antifoulant paint applied to recreational crafts (i.e., boats) was assessed for residential handlers.

Also addressed are postapplication exposures which can occur to individuals who are involved in industrial activities following application of zinc pyrithione pesticides, and those in contact with zinc pyrithione-treated end products in residential sites. Estimates of postapplication exposure to the chemical compound from contact with zinc pyrithione-treated articles are presented for residential adults and children, including child incidental non-dietary oral ingestion pathways. Potential dietary exposures from indirect food contact are not addressed in this chapter and are presented as part of the human health risk assessment document.

The exposure scenarios developed for this RED Chapter are representative of potential occupational and residential exposures to zinc pyrithione preservative over short-term (1 day to 1 month), intermediate-term (1-6 months), and long-term (> 6 months) exposure durations. The target MOE is 100 for occupationally exposed workers, while the target MOE is 300 for residential exposures.

At present, there are no available chemical-specific occupational exposure monitoring studies meeting Agency guidelines that can be relied upon to assess handler and postapplication exposures to zinc pyrithione. Therefore, inhalation and dermal exposure dose estimates were developed for occupational handler populations using surrogate data from the Chemical Manufacturers Association (CMA) Antimicrobial Exposure Assessment Study (CMA, 1992), the *Pesticide Handlers Exposure Database (PHED) Version 1.1* (PHED, 1997), and a literature exposure study on antifoulant paints (Garrod et al. 2000). CMA surrogate data and approaches derived from the EPA *Residential Exposure Assessment Standard Operating Procedures (SOPs)* (U.S. EPA, 1997a, 2001) were used for handler and postapplication assessments for residential populations.

In addition, several studies which relate to the use patterns of zinc pyrithione were used to estimate postapplication exposure. These studies, combined with guidance from EPA SOPs, were used to develop the postapplication section. Most notably, an exposure assessment submitted to EPA in support of the reregististration requirements of zinc pyrithione entitled "Health Assessment of the Use of Zinc Pyrithione Incorporated Into Polyurethane Sole Liners of Shoes" (MRID 441086-01) (Olin Corporation, 1996) was used in conjunction with leach rate data from an FDA Migration Study (MRID 441086-02) (U.S. EPA, 2000) as "surrogate" data to calculate dermal exposures to the preservative incorporated into polymeric materials.

Potential non-dietary exposures via oral ingestion of residues from surfaces of treated polymeric articles (i.e., infant object-to-mouth and hand-to-mouth contact) were addressed using "surrogate" exposure information from "Risk Analysis For Microban Additive "B" (Triclosan or Irgasan DP300) Treated Toys For Infants (Dang, 1997), MRIDs 441086-01 and 441086-02 and the Residential SOPs (2001).

Using surrogate unit exposure data, use application rates from EPA-registered product labels, and Agency-derived estimates of daily amounts handled, a variety of handler and postapplication exposures and risks were assessed.

Handlers

Based on the EPA-registered use patterns, appropriate primary and secondary handler exposure scenarios were identified for zinc pyrithione. In general terms, EPA defines "primary" handler exposure as direct exposure to the pesticide formulation during mixing/loading/applying operations. "Secondary" handler exposure is defined as exposure to a pesticide active ingredient as a direct result of its incorporation into an end product.

Primary Occupational Handlers. The exposure and risk assessment for primary occupational handlers was conducted using product label maximum application rates, related use information from Arch Chemicals, Inc., Agency standard values for industrial practices, and CMA unit exposure data. For mixing/loading liquids and powders in closed systems (i.e., using a metered pump, or automatic-dispensing techniques), the margin of exposure (MOE) calculations indicate risks not exceeding the Agency's level of concern (i.e., target MOEs $\geq$100) for the dermal and inhalation exposure scenarios assessed. The "dermal" exposure risks are not of concern (i.e., MOE $\geq$100) for potential short-term, intermediate-term, and long-term exposures during open mixing/loading of liquids for all the scenarios assessed. Also, the dermal and inhalation MOEs for the laundered fabrics scenarios were not of concern. However, MOEs for dermal and inhalation exposures exceed the Agency's level of concern (i.e., MOEs < 100) for short-term, intermediate-term, and long-term exposure scenarios during:

- mixing/loading/applying powders and liquids for <u>general preservative</u> use patterns using open pour methods (inhalation MOE=53 for liquid formulations; inhalation MOE=15 for powder formulation; and, dermal MOE = 42 for powder formulation); and

- mixing/loading/applying powders and liquids for <u>paint</u> preservation using open pour methods (inhalation MOE=53 for liquid formulations; inhalation MOE=15 for powder formulation; and, dermal MOE = 42 for powder formulation).

The Agency may consider requiring risk mitigation steps, such as closed delivery systems or use of a respirator during open pouring and has discussed these options with the registrant. Arch Chemicals, Inc. is considering amending the labeling for the "manufacturing use" industrial end-use powder and dispersion products to require workers to wear a NIOSH approved full face respirator equipped with a combination organic vapor/P100 cartridge during handling. This personal protective equipment (PPE) is anticipated to reduce inhalation exposure by 99.97%.

Secondary Occupational Handlers. Secondary occupational handler exposures could occur through the application of treated paints and coatings, and building materials such as caulks, adhesives, spackling, groutings, sealants, stucco and joint cements. Based on end-use product application methods and use amounts, it is assumed that exposures while applying paints will be equal to or greater than exposures while applying building materials. Therefore, occupational handler exposures were assessed for the application of paint, as this scenario represents maximum possible exposure to the chemical. Under this scenario, dermal and inhalation exposures were assessed for brush, airless sprayer, and aerosol application methods using *PHED Version 1.1* data.

Using product label maximum application rates, related use information, Agency standard values, and PHED unit exposure data, the secondary handler potential short-term, intermediate-term, and long-term MOEs exceed the Agency's level of concern (MOEs <100) for:

- handling zinc pyrithione-containing paint products (as a material preservative) using an airless sprayer application method (inhalation MOEs= 4 without PPE and 44 with the use of an organic vapor respirator as PPE; and, dermal MOEs=11 without PPE and 29 with the use of gloves as PPE), and

- handling zinc pyrithione-containing paint products (as a material preservative) using a paint brush application method (dermal MOE=22 without glove PPE).

It is assumed that in real-use situations for airless sprayer applications, the occupational handlers will have adequate respiratory protection by wearing either a dust/mist or organic vapor respirator as PPE recommended by paint manufacturers for spray equipment applications. Although the dermal MOEs for airless spray painting operations are of concern both with and without the use of gloves as PPE, it is assumed that in real-use situations the occupational handlers will have adequate dermal protection by wearing gloves as may be recommended by paint manufacturers during spray equipment applications. The dermal MOE for the paint brush scenario is not of concern (MOE=167) when gloves are worn as dermal protection. Although the secondary occupational handler assessments include PPE considerations, the mandatory use of PPE by handlers for non-spray applications of paint (i.e., paint brush) is not considered a viable protective measure due to probable non-compliance among paint handlers even if the zinc pyrithione-treated paint end products have labeling requiring the use of PPE. Arch Chemicals, Inc. plans to conduct certain confirmatory toxicity studies to reduce toxicological database uncertainties for zinc pyrithione which will aid the Agency in refining selection of toxicological endpoints and uncertainty factors used to assess dermal/inhalation exposure risks for paint applicators.[1] Dermal and inhalation MOEs obtained for the aerosol spray painting scenario were found to be of no risk concern. There were also no inhalation risk concerns for the paint brush scenario.

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[1] Proposed confirmatory studies to be conducted in support of reregistration include a 21-day nose-only inhalation study with a 5-day interim sacrifice; a 7-day range-finding inhalation study; a 21-day dermal study with a 5-day interim sacrifice; a 7-day range-finding dermal study; an acute and subchronic neurotoxicity characterization study in rats (GLN 870.6200) using the TGAI; and a dermal absorption study in rats (GLN 870.7600) using a typical preserved paint formulation at 0.5% a.i.(material preservative use pattern) and maximum antifoulant paint formulation at 5.0% a.i.(antifoulant use pattern), or a dermal developmental study in rats (GLN 870.3700) using the TGAI.

Primary Residential Handlers. Zinc Pyrithione is an antifouling agent used to control slime and algae growth below the water line of recreational and commercial boat hulls in fresh, salt, or brackish water. Recreational boat owners have several techniques they can use to paint their hulls including paint brush, roller, and airless sprayer. There are no chemical-specific exposure data to assess these techniques. However, surrogate data are available from PHED for painting with a brush and an airless sprayer. The surrogate data are based on test subjects painting a bathroom with a paint brush and staining the outside of a house with an airless sprayer, using no dermal or respiratory PPE. The dermal and inhalation exposures from these techniques have been normalized by the amount of active ingredient handled and reported as *unit exposures (UE)* expressed as mg/lb ai handled. Although the exposures while painting a boat hull may differ slightly, the data are judged to be representative of painting and are used in this assessment. In addition, Garrod et al (2000) measured both inhalation and dermal exposures during the painting of recreational boat hulls. However, the dermal portion of this study only measured a limited number of outside patches on the test subject's clothing. Therefore, only the air concentration measurements from Garrod et al (2000) are used to estimate MOEs.

Calculation of dermal and inhalation MOEs for residential use of antifoulant boat paint showed that dermal and inhalation MOEs were of concern (i.e. < 300) for all boat sizes when using either a paint brush or an airless sprayer application method, as follows:

- residential handlers painting boat hulls using an airless sprayer (<u>antifoulant paint use</u> for all boat sizes: dermal MOEs=15-78; inhalation MOEs=6-33); and

- residential handlers painting boat hulls using a brush (<u>antifoulant paint use</u> for all boat sizes: dermal MOE=3-17; inhalation MOE=18-97 using PHED, and inhalation MOE= 5-140 using Health and Safety Executive (HSE) data (Garrod et al. 2000).

It is important to note that the inhalation exposure risk estimates are conservative because the toxicity endpoint used in the assessment is based on a whole-body rat 90-day inhalation study. As a proposed risk mitigation measure, Arch Chemicals, Inc. and its end-use registrants of residential use antifouling paints will add a recommendation to its labeling to preclude the use of airless spray for residential antifoulant paint applications. Arch Chemicals, Inc. also proposes to limit the amount of zinc pyrithione active ingredient in formulated antifouling paints to 5%. Also, the planned confirmatory toxicity studies to be conducted by Arch Chemicals, Inc., as noted above for secondary occupational handlers, will provide useful data to refine the residential assessment for recreational boat paint applicators. In addition, International Paint (Akzo Nobel), a registrant of antifoulant end-use paint products containing zinc pyrithione, plans to submit data from an antifoulant painting study (referred to by Arch Chemicals, Inc. as the "residential applicator study") conducted in Scotland where amateurs were monitored using dermal/inhalation dosimetry during paint roller applications.

Secondary Residential Handlers. An assessment for primary residential handlers was not conducted in support of reregistration for the materials preservative use patterns because only industrial workers handle the EPA-registered zinc pyrithione pesticides; rather, residential populations are secondary handlers of consumer end products for which zinc pyrithione has been incorporated during the manufacturing process (i.e, zinc pyrithione-treated articles).

Secondary residential handler exposures could occur through the application of treated paints and coatings, and building materials such as caulks, adhesives, spackling, groutings, sealants, stucco and joint cements. Based on end-use product application methods and use amounts, it is assumed that exposures while applying paints will be equal to or greater than exposures while applying building materials. Therefore, residential handler exposures were assessed for the application of paint, as this scenario represents maximum possible exposure to the chemical. Under this scenario, dermal and inhalation exposures were assessed for brush, airless sprayer, and aerosol application methods using *PHED Version 1.1* values found in the *Residential Exposure SOPs* (U.S. EPA, 1997a, 2001)**.** The surrogate exposure data in PHED are based on test subjects painting a bathroom with a paint brush and staining the outside of a house with an airless sprayer. The dermal and inhalation exposures from these techniques have been normalized by the amount of active ingredient handled and reported as *unit exposures (UE)* expressed as mg/lb ai handled. The residential scenarios are similar to those developed for secondary occupational handlers, only the use rates and residential PHED data are modified.

Using product label maximum application rates, related use information, Agency standard values, and PHED unit exposure data, the secondary handler short-term, intermediate-term, and long-term MOEs exceed the Agency's level of concern (MOEs <300) for the following scenarios:

- handling zinc pyrithione-containing paint products (as a material preservative) using a paint brush application method (dermal MOE=44);

- handling zinc pyrithione-containing paint products (as a material preservative) using an airless sprayer application method (dermal MOE=17; inhalation MOE=15); and

- handling zinc pyrithione-containing paint products (as a material preservative) using an aerosol spray can application method (inhalation MOE=271).

It cannot be assumed that residential handlers using spray painting methods will adequately protect themselves from dermal and inhalation exposure by wearing respiratory protection (e.g., a dust mask or organic vapor respirator as may be recommended by paint manufacturers for spray applications) and chemical-resistant gloves while painting. However, the confirmatory toxicity studies to be conducted by Arch Chemicals, Inc., as previously noted, will provide useful data to refine the residential assessment for applicators of zinc pyrithione-preserved architectural paints.

Postapplication Exposures

Postapplication exposures refer to those potential exposures which may occur to handlers while involved in postapplication or reentry activities following application of the pesticide concentrate or formulated end-use product. Postapplication exposures also result from bystander contact with treated surfaces/articles and while occupying areas where pesticide end-use products have recently been applied (e.g. treated duct work). Zinc pyrithione has a low vapor pressure (i.e.,$<$1.87x10-9 torr @25°C) and is, therefore, not likely to generate sufficient vapor to cause an inhalation concern to occupational and residential populations performing postapplication tasks, or occupying recently treated areas, or from bystander contact with treated articles. Therefore, postapplication inhalation exposures were not assessed.

Primary Occupational Postapplication. Primary occupational postapplication inhalation exposures are limited to mists, steams, or vapors resulting from manufacturing process operations. Occupational postapplication dermal and inhalation exposures to zinc pyrithione are likely to be minimal compared to handler exposure because of the dilution of the biocide during processing. Since primary occupational postapplication exposures are likely to be brief and pesticide concentrations are expected to be more diluted, a risk assessment is not required.

Secondary Occupational Postapplication. Secondary occupational postapplication exposures result when bystanders come in contact with zinc pyrithione in areas where pesticide-treated end-use products have recently been applied (e.g., freshly painted walls). Workers could have dermal and inhalation exposures to zinc pyrithione-treated adhesives, caulks, sealants, and paints. However, since the paint, caulks and sealants are expected to dry within a day, potential dermal and inhalation exposures are expected to be minimal. Exposures resulting from contact with treated fabrics/textiles, polymeric materials and related treated substances are expected to be negligible because of limited transfer of product residues and product dilution. Consequently, postapplication dermal exposures were not quantitatively evaluated in this report.

Residential Postapplication. Residential postapplication exposures result when bystanders (adults and children) come in contact with zinc pyrithione in areas where pesticide-treated end-use products have recently been applied (e.g., freshly painted walls or boat hulls of recreational craft), or when children incidentally ingest the pesticide residues through mouthing the treated end products/treated articles (i.e., hand-to-mouth or object-to-mouth contact). As noted previously for the occupational scenarios, postapplication dermal exposures are expected to be minimal because the paint is expected to dry within a day. Thus, postapplication dermal exposures to paint were not quantitatively evaluated in this report. Dermal exposures to plastic treated with zinc pyrithione, such as shoe liners, were evaluated and determined not to be of concern (MOEs =1,231-4,500). In addition, non-dietary incidental ingestion exposures of children via object-to-mouth and hand-to-mouth activities did not exceed the Agency's level of concern (MOE > 300) for contact with treated polymeric articles (e.g., household furnishings/articles). Aggregate postapplication residential exposures for a young child were also greater than the target MOE of 300, and are not of concern.

Occupational and Residential Risk Characterization

The exposure and risk assessment conducted for occupational and residential populations and use patterns indicated the following:

- Primary occupational handlers of registered zinc pyrithione industrial pesticides are best protected under conditions where automated pesticide delivery systems are used as engineering controls. Where feasible, closed delivery systems will mitigate the exposure concerns for industrial handlers of powder formulations (dermal and inhalation) and liquid concentrates (inhalation);

- Inhalation exposure to zinc pyrithione is of concern for primary occupational handlers using "open pour" methods (assessed as wearing no respiratory PPE as typical work conditions). As risk mitigation, Arch Chemicals, Inc. is considering amending the labeling for the "manufacturing use" industrial end-use powder and dispersion products to require workers to wear a NIOSH approved full face respirator equipped with a combination organic vapor/P100 cartridge during handling. This PPE is anticipated to reduce inhalation exposure by 99.97%;

- Dermal and inhalation exposures were of concern for primary residential handlers of zinc pyrithione antifoulant paints from both brush and airless spraying applications. As a proposed risk mitigation measure, labeling will be amended to preclude the use of airless spray for residential antifoulant paint applications. Arch Chemicals, Inc. also proposes to limit the amount of zinc pyrithione active ingredient in formulated antifouling paints to 5%;

- Secondary occupational and secondary residential handlers of zinc pyrithione-treated products (as a <u>material preservative</u>) (e.g., paints, caulks) are best protected under conditions where adequate dermal and inhalation protection occur in the form of PPE (especially respiratory protection during paint spraying applications). The Agency has no regulatory purview over consumer goods which meet the FIFRA "treated articles exemption";

- Postapplication inhalation and dermal exposures to occupational and residential adult populations are not a concern; and

- Postapplication exposures to child populations handling and mouthing treated objects (i.e., treated household articles) are not a risk concern.

2.0 OCCUPATIONAL AND RESIDENTIAL EXPOSURE AND RISK ASSESSMENT

A. Toxicological Considerations

(1) Criteria for Conducting Exposure Assessments

An occupational and/or residential exposure and risk assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is potential exposure to handlers (mixers, loaders, applicators) during use or to persons entering treated sites after application is complete. For zinc pyrithione, both criteria are met.

(2) Summary of Toxicity Concerns Relating to Occupational and Residential Non-Dietary Exposures

(a) Acute Toxicology Categories

Acute toxicity categories for zinc pyrithione are shown in Table 1.

Table 1. Acute Toxicity Categories for Zinc Pyrithione

Test	Results	Toxicity Category
Acute Oral Toxicity	LD50=267 mg/kg	II
Acute Dermal Toxicity	LD50 > 2000 mg/kg	III
Acute Inhalation Toxicity	LC50 > 0.61 mg/L	III
Primary Eye Irritation	Severe Irritant	I
Primary Dermal Irritation	Slight Erythema and Edema	IV
Dermal Sensitization	No Dermal Sensitization Observed	NA

As indicated above, zinc pyrithione is moderately toxic by the oral route, but acute toxicity by the dermal route is not as significant. Acute toxicity by the inhalation route is also relatively low. Zinc pyrithione is a severe eye irritant (Toxicity category I) but does not appear to demonstrate significant dermal irritation nor dermal sensitization potential. Non-acute toxicity studies with zinc pyrithione demonstrate developmental toxicity as well as neurotoxicity. Based on this, a developmental endpoint was selected for the occupational and adult residential dermal exposure assessments.

(b) Summary of Toxicological Endpoint Selection

OPP's Antimicrobial Division Toxicology Endpoint Selection Committee (ADTC) (2004) has identified toxicological endpoints of concern (EPA, 2004). Table 2 summarizes these endpoints. A developmental endpoint was selected for short-, intermediate-, and long-term dermal exposures for occupational and adult residential scenarios. The developmental no-observed-adverse-effect level (NOAEL) of 0.5 mg/kg/day was based on a development toxicity study in rabbits for gestation days 6-18 in which toxic effects such as increased post implantation loss and decreased viable fetuses were observed at a low-observed-adverse-effect level (LOAEL) of 1.5 mg/kg/day.

In addition to the endpoint selected for dermal exposures, inhalation endpoints of concern have been identified for short-, intermediate-, and long-term inhalation exposures. The NOAEL selected was 0.0005 mg/L/day based on toxic effects including labored breathing, rales, increased salivation, decreased activity, dry red-brown material around the nose, increased absolute and relative lung weights, and death of undetermined cause (MRID 428279-03). Since the NOAEL was presented in mg/L/day, it was necessary to convert the dose to mg/kg/day because exposure doses are presented in these units. A route-to-route extrapolation equation was used to convert human and animal values from "mg/L/day" concentrations to "mg/kg/day." Using the "Route-to-Route Extrapolation" presented by EPA, the dose of 0.0005 mg/L/day converts to 0.13 mg/kg/day (U.S. EPA, 1998).

Equation 1

$$\frac{mg/L/day \times A \times RV \times D \times AF}{BW} = mg/kg/day$$

where:

A	=	Absorption. The ratio of deposition and absorption in the respiratory tract compared to absorption by the oral route. 100% absorption is assumed for inhalation.
RV	=	Respiratory Volume (RV) is 10.26 L/hr/kg for male and female Sprague-Dawley rats.
D	=	Duration (D) of daily animal or human body weight in kg. Duration of the rat study was 6 hr/day.
AF	=	Activity Factor (AF) for animals is 1.
BW	=	Mean animal weight for Sprague-Dawley rats is 0.236 kg.

Table 2. Toxicological Endpoints for Assessing Occupational and Residential Exposures/Risks			
Exposure Scenario	**Dose (mg/kg/day)**	**Endpoint**	**Study**
Acute Dietary Exposure (females 13+)	Developmental NOAEL = 0.5 UF = 100 FQPA=1X DB=3X	Increased post implantation loss and decreased viable fetuses were observed at LOAEL = 1.5 mg/kg/day	Developmental Toxicity Study in Rabbits for gestation days 6-18
Acute Dietary Exposure (general population & infants/children)	Maternal NOAEL = 0.75 UF = 100 FQPA=1X DB=3X	Maternal toxicity characterized as increased salivation observed at LOAEL = 3.0 mg/kg/day	Developmental Toxicity Study in Rats for gestation days 6-15
Chronic Dietary Exposure - Reference Dose (all populations)	Developmental NOAEL = 0.5 UF = 100 FQPA=1X DB=3X	Increased post implantation loss and decreased viable fetuses were observed at LOAEL = 1.5 mg/kg/day	Development Toxicity Study in Rabbits for gestation days 6-18
Short-, Intermediate-Term Oral Exposure	NOAEL = 0.75 Target MOE= 300 Residential	Maternal toxicity characterized as increased salivation at were observed at LOAEL = 3.0 mg/kg/day	Developmental Toxicity Study in Rats for gestation days 6-15
Short-, Intermediate-, and Long-Term Dermal Exposure	Developmental NOAEL=0.5 (Occupational & Residential - Adult)* Target MOEs= 100 Occupational 300 Residential	Increased post implantation loss and decreased viable fetuses were observed at LOAEL = 1.5 mg/kg/day	Development Toxicity Study in Rabbits for gestation days 6-18
	Dermal NOAEL = 100 (Residential - Child) Target MOE= 300 Residential	Decreased body weight gain and food consumption/food efficiency at LOAEL = 1000 mg/kg/day	90-day Subchronic Dermal Toxicity Study in Rats
Short-, Intermediate-, and Long-Term Inhalation Exposure	Inhalation NOAEL= 0.0005 mg/L (i.e., 0.13 mg/kg/day) Target MOEs= 100 Occupational; 300 Residential	Clinical signs of toxicity, decreased activity, and increased lung weights at LOAEL = 0.0025 mg/L	90-day Subchronic Inhalation Toxicity Study in Rats
Oral Cancer Slope Factor	No chronic or carcinogenicity studies are available to assess the carcinogenic potential of zinc pyrithione	N/A	N/A

UF = Uncertainty Factor
NA = Not applicable

Recommended MOEs of 100 for the occupational assessment are based on applied uncertainty factors of 10x to account for inter-species extrapolation, and 10x for intra-species variability.
FQPA SF = An additional 1x is applied as an FQPA safety factor for the non-dietary oral (incidental ingestion) residential MOEs calculated in this assessment.
DB UF = An additional 3x is applied as a database uncertainty factor for all residential MOEs calculated in this assessment.

* For occupational and adult residential exposure a dermal absorption factor of 3% is applied since an oral developmental endpoint was selected for dermal risk assessment.

For the residential postapplication assessment, it was necessary to address potential exposures through both the dermal route (adults and children) and oral route (child incidental ingestion via hand-to-mouth and direct mouthing of treated articles). The NOAEL of 0.75 mg/kg/day selected by the ADTC/HIARC for acute dietary exposure (general population and infants) was based on evidence of increased salivation in dams at a LOAEL of 3.0 mg/kg/day (MRID 428279-05) (U.S. EPA, 1999a). This endpoint was used for short-, and intermediate-term child incidental oral exposure. The NOAEL selected for short-, and intermediate-term child dermal exposure was 100 mg/kg/day, based on a 90 day dermal toxicity study in which toxic effects were observed in rats causing decreased body weight gain and food consumption/food efficiency (MRID 428279-02).

The 1999 HIARC report also addressed the potential increased susceptibility of infants and children from exposure to zinc pyrithione as required by the Food Quality Protection Act (FQPA) of 1996. However, a subsequent evaluation of the hazard and exposure data for zinc pyrithione was conducted by the Health Effects Division's FQPA Safety Factor Committee on August 7, 2001 for the purpose of determining the appropriate safety factor under FQPA. They initially recommended that an additional safety factor of 10x be retained for zinc pyrithione and that this factor be applied to all population subgroups for assessing residential risks. Since that time, changes to the application of the FQPA safety factor have been published by the Agency. For zinc pyrithione, while the rat and rabbit developmental toxicity studies show qualitative evidence of increased susceptibility, there is an adequately characterized endpoint in both studies. Thus, the effects observed in offspring in the developmental toxicity studies can be used to select dietary endpoints for assessing incidental oral ingestion exposure, and are thus protective of infants and children. Therefore, the special FQPA safety factor is reduced to 1x. However, a database uncertainty factor of 3x is applied to all assessed residential exposure scenarios (i.e., oral, dermal and inhalation routes) due to a lack of characterization of neurotoxic dose-response relationships for zinc pyrithione (U.S. EPA, ADTC 2004).

For assessing all potential occupational exposures, a margin of exposure (MOE) of 100 was selected. For the residential exposure assessment an FQPA safety factor (1x) and a database uncertainty factor (3x) were applied resulting in the selection of an MOE of 300 for the non-dietary oral exposure scenarios. The database uncertainty factor (3x) was also applied to all assessed residential dermal and inhalation exposure scenarios for a selected MOE of 300.

Studies with zinc pyrithione were not available to address chronic toxicity and carcinogenicity for this chemical. [Data on the carcinogenic potential of a related compound, sodium pyrithione, showed no evidence of carcinogenicity, and was classified as a Group D (not classifiable as to carcinogenicity) carcinogen by the Health Effects Division Carcinogenicity Peer Review Committee.] Therefore, a cancer risk assessment was not conducted since carcinogenic endpoints related to lifetime average absorbed doses of zinc pyrithione from occupational and residential exposures have not been identified.

(c) Dermal Absorption

For the occupational and adult residential scenarios, a dermal absorption factor of 3% is required because an oral developmental NOAEL was selected for assessing dermal risk. It is noted that the 3% dermal absorption factor demonstrated in the swine study is supported by a literature study in mice which also showed a dermal absorption of 3% (U.S. EPA, 1999a). A dermal absorption factor is not required for the child residential assessment since a dermal endpoint was used.

B. Occupational and Residential Exposures

(1) Handler Exposures

EPA has determined that there is a potential for exposures to mixers, loaders, applicators, or other handlers associated with the registered use patterns of zinc pyrithione pesticide products. There are potential exposures from use in commercial, industrial, and residential settings via the dermal and inhalation routes. EPA has identified the following levels of handler exposures:

- *Primary Handlers* -- Defined as persons having direct exposure to the pesticide formulations during mixing/loading/applying operations. For this RED, primary handlers are "occupational handlers" of EPA-registered zinc pyrithione pesticide product concentrates used for industrial manufacturing purposes as dry film, in can, and general materials preservatives for incorporation into various substrates prone to fungal and bacterial degradation (e.g., water-based emulsions, coatings, slurries, thermoplastic resins, rubber, textiles, and polymeric systems). In addition, do-it-yourself (D-I-Y) painters are considered primary handlers for antifoulant paints (i.e. boat owner's painting hulls of recreational boats in residential settings).

- *Secondary Handlers* -- Defined as persons having direct exposure to the pesticide active ingredient as a result of its incorporation into manufactured end products. Exposure occurs during normal use patterns of the end products. For this RED, secondary handlers are both "occupational handlers" and "residential handlers" of caulks, sealants, paints, and other end products to which zinc pyrithione has been added as a preservative.

EPA has identified the following exposure scenarios for primary occupational handlers, secondary occupational handlers, and primary and secondary residential handlers. These exposure scenarios are further developed in Table 4 for each of the major registered materials preservation use patterns. A separate section details the scenarios for residential handlers of antifoulant paints.

Primary Occupational Handlers *(Materials Preservatives)*

- mixing/loading/applying liquid zinc pyrithione pesticide product concentrates using open pour methods.

- mixing/loading/applying liquid zinc pyrithione pesticide product concentrates using metering equipment (pump liquid).

- mixing/loading/applying powder zinc pyrithione pesticide product concentrates using open pour methods.

- mixing/loading/applying powder zinc pyrithione pesticide product concentrates using metering equipment (automatic-dispensing techniques).

Secondary Occupational Handlers *(Materials Preservatives)*

- handling zinc pyrithione-containing paint end products using paint brush, airless sprayer, and aerosol spray can application methods.

Primary Residential Handlers *(Antifoulants)*

- handling zinc pyrithione-containing antifoulant paints using a paint brush.

- handling zinc pyrithione-containing antifoulant paints using an airless sprayer.

Secondary Residential Handlers *(Materials Preservatives)*

- handling zinc pyrithione-containing paint end-products using paint brush, airless sprayer, and aerosol spray can application methods.

(a) Antifoulant Use Pattern

Zinc Pyrithione is an antifouling agent used to control slime and algae growth below the water line of recreational and commercial boat hulls in fresh, salt, or brackish water. Zinc pyrithione is incorporated into antifoulant paint formulations at maximum rates up to 50,000 ppm active ingredient (i.e., maximum incorporation into paint matrices at 5% a.i.). There are currently eleven registered products containing zinc pyrithione for antifoulant uses: two are for formulator use in manufacturing antifoulant paints, and of the other nine, one is a paint concentrate (as part of a two-component mixture), and eight are ready-to-use paints. The registered antifoulant paint end products bear labeling with specified use patterns, application methods and personal protective equipment (PPE). Labeling for the following nine formulated paint products (EPA Reg. Nos.) shown in Table 3 have been reviewed and representative products selected for the residential handler assessment:

Table 3. Zinc Pyrithione Antifoulant Paint Use Pattern		
EPA Reg. No.	**Percent (%) Zinc Pyrithione in Formulation**	**Use Pattern**
2693-187	3.8 %	Limited to commercial use only. No restrictions on application methods. Requires eyewear, long pants, long-sleeved shirt, hat, gloves, and respirator. (Accepted label 12/6/2001)
2693-188	3.18 %	Limited to commercial use only. No restrictions on application methods. Requires eyewear, long pants, long-sleeved shirt, hat, gloves, and respirator. (Accepted label 9/7/2000)
2693-194	**47.04 %**	**No restrictions on use but does not specifically mention recreational boats. No restrictions on application methods. This is the Activator product portion of a two-part mixture. Requires eyewear only. (Accepted label 5/2/2002)**
2693-200	3.04 %	No restrictions on use but does not specifically mention recreational boats. Application methods listed as brush or roller and that "spraying is not recommended". Requires eyewear, long pants, long-sleeved shirt, hat, gloves, and respirator. Product can be thinned up to 10% and covers 320 ft^2/gallon at a 2 mil dry film thickness. (Accepted label 10/3/2002)
2693-203	3.39 %	Label specifically mentions small craft and car top boats. Application methods listed as brush or roller and that "spraying is not recommended". Requires eyewear, long pants, long-sleeved shirt, hat, gloves, and respirator. Product can be thinned up to 10 to 25% and covers 400 ft^2/gallon and recommends a minimum of 3 coats. (Accepted label 10/3/2002)
48302-11	2.91%	Limited to commercial use only by professional applicators. Application methods listed as spray, brush or roller. Requires eyewear, long pants, long-sleeved shirt, gloves, and respirator. Product can be thinned up to 5% and covers 192 ft^2/gallon at a 4 mil dry film thickness. (Accepted label 8/12/2003)
60061-116	2.5%	Label specifies use on commercial and recreational vessels of any size. No label restriction for professional applicator only. Application methods listed as brush, roller or spray. Requires coveralls worn over long pants and long-sleeved shirt, chemical-resistant gloves, eyewear, socks, and chemical resistant footwear. Use of a NIOSH/MSHA certified mask or respirator while spraying and/or sanding boat surfaces. Thinning is not recommended for brush /roller and up to 10 percent for spraying. A minimum of 2, preferably 3 coats, is recommended and covers 440 ft^2/gallon at a 2 mil dry film thickness. (Accepted label 3/10/2004)
64684-4	**4.8 %**	**Label specifies commercial and recreational use. Application methods listed as brush or roller but does not prohibit spraying. Requires eye wear, long pants, long-sleeved shirt, hat, and gloves while "*spraying, sanding or blasting the paint*" and respirator. Unclear if PPE is for the preparation of the hull or for the painting. Thinning is not recommended and recommends a minimum of 3 coats. (Accepted label 3/17/2000)**
64684-6	4.7 %	No restrictions on use but does not specifically mention recreational boats. Application methods listed as brush, roller, and spraying. Requires eyewear, long pants, long-sleeved shirt, hat, and gloves while *"spraying, sanding or blasting the paint"* and respirator. Unclear if the PPE is for the preparation of the hull or for the painting. Thinning is not recommended for brush and roller and up to 10 percent for spraying. A minimum of 3 coats is recommended and covers 300 ft^2/gallon. (Accepted label 3/17/2000)

Note: Bold denotes products used for the residential handler assessment which were selected as representative of the range of registered antifoulant end products.

(b) Materials Preservation Use Pattern

Zinc Pyrithione is used as an industrial preservative to prevent decay and maintain the integrity of manufacturing precursor materials and manufactured articles. Zinc pyrithione is a bacteriostat, fungicide, microbiocide/microbiostat registered for use in food packaging adhesives (indoor food), dry film preservation of architectural/industrial non-marine paints (indoor/outdoor nonfood), control of bacterial growth on laundered products (indoor nonfood), and materials preservation of adhesives, caulks, patching compounds, sealants, grouts, latex paints, coatings, dry wall, gypsum, pearlite, and plaster (indoor nonfood). Zinc pyrithione is used for the control of mildew in nonfood contact polymers and control of mildew and bacteria in styrene butadiene rubber and thermoplastic resins. Materials preservation extends to in-can preservation of clay, mineral, pigment and guar gum slurries, latex emulsions, and similar high solids aqueous media.

There are currently seven registered industrial end-use products containing zinc pyrithione for use as a materials preservative that are eligible for reregistration under Case 2480. They range in active ingredient concentration from 5% a.i. to 95% a.i. and are sold as powder, liquid, and aqueous dispersion (solids in liquid) formulations. The end-use products are applied during the manufacturing process of the incorporated treated articles and treated article precursor materials. Zinc Pyrithione formulations are added at maximum rates up to 5000 ppm active ingredient (i.e., incorporation into treated materials at 0.5% a.i.) using both open pouring and closed delivery systems. They are added at a point where thorough mixing takes place. For preservation of laundered fabrics/textiles, zinc pyrithione is incorporated at maximum rates of 56 ppm active ingredient (i.e., 0.005% a.i.) during the laundry sour operation. Variations in formulations, conditions of use, and desired degree of protection for the manufactured articles/substrates determines the pesticide use rates. Representative scenarios developed for the materials preservation use pattern are detailed in Table 4.

The resulting manufactured zinc pyrithione-treated end products which are sold or distributed are exempt from pesticide registration requirements under FIFRA if they qualify as treated articles under the “treated articles exemption” [40 CFR, Part 152.25(a)]. The "treated articles exemption" provides an exemption from FIFRA requirements for qualifying articles or substances treated with, or containing a registered pesticide if (1) the incorporated pesticide is registered for use in or on the article or substance itself, and (2) the sole purpose of the treatment is to protect the article or substance itself, not to provide additional pesticidal (antimicrobial) benefits.

Table 4. Exposure Scenarios for Occupational/Residential Handlers	
Exposure Scenario	**Scenario Description**
Primary Occupational Handler	
General Preservative Uses: Dry Film, In Can, and Materials Preservation	
(1a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	Scenario encompasses a variety of general preservatives use patterns (i.e., dry film, in can, and materials preservation) where the pesticide is incorporated into various substrates (e.g., food/non-food contact adhesives, water-based emulsions, coatings, slurries, thermoplastic resins (e.g. air ducts), rubber, textiles, and food/non-food contact polymeric systems; including repeat-use polymeric food contact materials such as manufactured food processing equipment and conveyor belts). The biocide is added using open pour methods. Potential exposures may occur during the open loading/applying of the concentrate into bulk tanks/mixing vats or other containers during manufacturing of the various substrates. The manufacturing of caulks/sealants from slurries treated for dry film or in can preservation was selected as the representative scenario. Unit exposures from CMA database for pouring liquid preservatives are used to calculate exposure (CMA, 1992).
(1b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	Scenario encompasses a variety of general preservatives use patterns (i.e., dry film, in can, and materials preservation) where the pesticide is incorporated into various substrates (e.g., food/non-food contact adhesives, water-based emulsions, coatings, slurries, thermoplastic resins (e.g. air ducts), rubber, textiles, and food/non-food contact polymeric systems; including repeat-use polymeric food contact materials such as manufactured food processing equipment and conveyor belts). The biocide is added using an automated metering system. Potential exposures may occur during the loading and setup/maintenance of the automated metering system during manufacturing of the various substrates. Liquid concentrates are pumped into tanks or bins and diluted into a slurry. The manufacturing of caulks/sealants from slurries treated for dry film or in can preservation was selected as the representative scenario. Unit exposures from CMA database for pumping liquid preservatives are used to calculate exposure (CMA, 1992).
(1c) Mixing/loading/applying powder pesticide concentrates using open pour methods	Scenario encompasses a variety of general preservatives use patterns (i.e., dry film, in can, and materials preservation) where the pesticide is incorporated into various substrates (e.g., food/non-food contact adhesives, water-based emulsions, coatings, slurries, thermoplastic resins (e.g. air ducts), rubber, textiles, and food/non-food contact polymeric systems; including repeat-use polymeric food contact materials such as manufactured food processing equipment and conveyor belts). The powder biocide is added using open pour methods into liquid slurries. Potential exposures may occur during the open loading/applying of the concentrate into bulk tanks/mixing vats or other containers during manufacturing of the various substrates. The manufacturing of caulks/sealants from slurries treated for dry film or in can preservation was selected as the representative scenario. Unit exposures from CMA database for solid pour are used to calculate exposure (CMA, 1992).

Table 4. Exposure Scenarios for Occupational/Residential Handlers	
Exposure Scenario	**Scenario Description**
(1d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	Scenario encompasses a variety of general preservatives use patterns (i.e., dry film, in can, and materials preservation) where the pesticide is incorporated into various substrates (e.g., food/non-food contact adhesives, water-based emulsions, coatings, slurries, thermoplastic resins (e.g. air ducts), rubber, textiles, and food/non-food contact polymeric systems; including repeat-use polymeric food contact materials such as manufactured food processing equipment and conveyor belts). The powder biocide is added using an automated metering system into liquid slurries. Potential exposures may occur during the loading and setup/maintenance of the automated metering system during manufacturing of the various substrates. The manufacturing of caulks/sealants from slurries treated for dry film or in can preservation was selected as the representative scenario. No unit exposure data were available to represent mixing/loading/applying of powder formulations in closed delivery systems. Therefore, CMA unit exposure data for general preservatives for pump liquid (a closed delivery system) are used as a surrogate to calculate exposure (CMA, 1992).
Paints: Dry Film Preservation	
(2a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	Scenario occurs when the pesticide is added at anytime during the paint manufacturing process for dry film preservation. The biocide is added using open pour methods. Potential exposures may occur during the loading/applying of the concentrate into bulk tanks/mixing vats for incorporation into paint formulations. CMA unit exposure data for general preservatives for pour liquid are used to calculate exposure (CMA, 1992).
(2b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	Scenario occurs when the pesticide is added at anytime during the paint manufacturing process for dry film preservation. The biocide is added using an automated metering system. Potential exposures may occur during loading and setup/maintenance of the automated metering system. CMA unit exposure data for general preservatives for pump liquid are used to calculate exposure (CMA, 1992).
(2c) Mixing/loading/applying powder pesticide concentrates using open pour methods	Scenario occurs when the pesticide is added at anytime during the paint manufacturing process for dry film preservation. The powder biocide is added using open pour methods. Potential exposures may occur during the loading/applying of the concentrate into bulk tanks/mixing vats for incorporation into paint formulations. CMA unit exposure data for general preservative for solid pour data are used to calculate exposure (CMA, 1992).
(2d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	Scenario occurs when the pesticide is added at anytime during the paint manufacturing process for dry film preservation. The powder biocide is added using an automated metering system. Potential exposures may occur during loading and setup/maintenance of the automated metering system. No unit exposure data were available to represent mixing/loading/applying of powder formulations in closed delivery systems. Therefore, CMA unit exposure data for general preservatives for pump liquid (a closed delivery system) are used as a surrogate to calculate exposure (CMA, 1992).
Fabrics/Textiles: Laundering Treatment for Materials Preservation	
(3a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	Scenario occurs when the pesticide concentrate is added to the "acid sour" operation during industrial laundering treatments of manufactured fabrics/textiles. The biocide is added in a recirculating water system using open pour methods. Potential exposures may occur via loading and filling bulk tanks, contact with wet laundered fabrics/textiles or exposure to mists or vapors from the laundry machines. Unit exposures from CMA database for pouring liquid preservatives are used to calculate exposure (CMA, 1992).

Table 4. Exposure Scenarios for Occupational/Residential Handlers	
Exposure Scenario	**Scenario Description**
(3b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	Scenario occurs when the pesticide concentrate is added to the "acid sour" operation during industrial laundering treatments of manufactured fabrics/textiles.The biocide is added in a recirculating water system using an automated metering system. Potential exposures may occur via loading and setup/maintenance of the automated metering system. Unit exposures from CMA database for pumping liquid preservatives are used to calculate exposure(CMA, 1992).
(3c) Mixing/loading/applying powder pesticide concentrates using open pour methods	Scenario occurs when the pesticide concentrate is added to the "acid sour" operation during industrial laundering treatments of manufactured fabrics/textiles. The powder biocide is added in a recirculating water system using open pour methods. Potential exposures may occur via loading and filling bulk tanks, contact with wet laundered fabrics/textiles or exposure to mists or vapors from the laundry machines. Unit exposures from CMA database for general preservatives for solid pour are used to calculate exposure (CMA, 1992).
(3d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	Scenario occurs when the pesticide concentrate is added to the "acid sour" operation during industrial laundering treatments of manufactured fabrics/textiles. The powder biocide is added in a recirculating water system using an automated metering system. Potential exposures may occur via loading and setup/maintenance of the automated metering system. No unit exposure data were available to represent mixing/loading/applying of powder formulations in closed delivery systems. Therefore, CMA unit exposure data for general preservatives for pump liquid (a closed delivery system) are used as a surrogate to calculate exposure (CMA, 1992).
Secondary Occupational Handler	
(4a Handling zinc pyrithione-containing paint end products using a paint brush application method	Scenario occurs when an occupational handler applies biocide-treated paint using a paint brush. PHED unit exposure data for paint brush are used (PHED, 1997).
(4b) Handling zinc pyrithione-containing paint end products using an airless sprayer application method	Scenario occurs when an occupational handler applies biocide-treated paint using an airless sprayer. PHED unit exposure data for airless sprayer are used (PHED, 1997).
(4c) Handling zinc pyrithione-containing paint end products using an aerosol spray can application method	Scenario occurs when an occupational handler applies biocide-treated paint using an aerosol spray can. PHED unit exposure data for aerosol spray are used (PHED, 1997).
Secondary Residential Handler	
(5a) Handling zinc pyrithione-containing paint end products using a paint brush application method	Scenario occurs when a residential handler applies biocide-treated paint using a paint brush. PHED unit exposures from the Residential SOPs are used for paint brushing by a residential handler (EPA 1997).
(5b) Handling zinc pyrithione-containing paint end products using an airless sprayer application method	Scenario occurs when a residential handler applies biocide-treated paint using an airless sprayer. PHED unit exposures from the Residential SOPs are used for airless spraying by a residential handler (EPA 1997).
(5c) Handling zinc pyrithione-containing paint end products using an aerosol spray can application method	Scenario occurs when a residential handler applies biocide-treated paint using an aerosol spray can. PHED unit exposures from the Residential SOPs are used for aerosol spraying by a residential handler (EPA 1997).

(2) Handler Exposure Data and Assumptions

In the development of this Reregistration Eligibility Decision (RED) Document, limited handler exposure data were available for use by the Agency. In the absence of chemical-specific data for zinc pyrithione, surrogate data from the *Pesticide Handlers Exposure Database (PHED) Version 1.1*, the Chemical Manufacturers Association (CMA), and Garrod et al. (2000) were used to estimate unit exposures. Zinc pyrithione product labeling information along with EPA use estimates were relied on to calculate the approximate amount handled per day. These data were used to predict handler exposures for the various scenarios (PHED, 1997; CMA, 1992; and U.S. EPA, 1997a).

(a) **Handler Exposure Data**

Chemical-specific handler exposure data were not submitted by the registrant for Zinc Pyrithione; therefore, surrogate data from CMA, PHED, the residential SOPs, and Garrod et al. (2000) were used to estimate exposure.

(i) Chemical Manufacturers Association (CMA) Data

The *CMA study* data were used to estimate primary exposures for the following occupational handler scenarios (Table 7).

Primary Occupational Handlers

General Preservative Uses: Dry Film, In Can, and Materials Preservative

(1a) Mixing/loading/applying liquid pesticide concentrates using open pour methods;
(1b) Mixing/loading/applying liquid pesticide concentrates using metering pump equipment (pump liquid);
(1c) Mixing/loading/applying powder pesticide concentrates using open pour methods; and
(1d) Mixing/loading/applying powder pesticide concentrates using metering equipment.

Paints: Dry Film Preservation

(2a) Mixing/loading/applying liquid pesticide concentrates using open pour methods;
(2b) Mixing/loading/applying liquid pesticide concentrates using metering pump equipment (pump liquid);
(2c) Mixing/loading/applying powder pesticide concentrates using open pour methods; and
(2d) Mixing/loading/applying powder pesticide concentrates using metering equipment.

Fabrics/Textiles: Laundering Treatment for Materials Preservation

(3a) Mixing/loading/applying liquid pesticide concentrates using open pour methods;
(3b) Mixing/loading/applying liquid pesticide concentrates using metering pump equipment (pump liquid);
(3c) Mixing/loading/applying powder pesticide concentrates using open pour methods; and
(3d) Mixing/loading/applying powder pesticide concentrates using metering equipment.

The CMA (1992) "Antimicrobial Exposure Assessment Study" was conducted in order to meet the requirements of Subdivision U of the Pesticide Assessment Guidelines for "Applicator Exposure Monitoring"[2] and the "Occupational and Residential Exposure Test Guidelines" in Series 875 to support the registration of antimicrobial pesticide active ingredients. The purpose of this CMA study was to characterize exposure to antimicrobial chemicals in order to support certain antimicrobial pesticide reregistrations (CMA, 1992). The unit exposures presented in the most recent EPA evaluation of the CMA database (EPA, 1999b) were used in this assessment.

The Agency determined that the CMA study had fulfilled the basic requirements of Subdivision U - Applicator Exposure Monitoring. The advantages of CMA data over other "surrogate data sets" are that the chemicals and the job functions of mixer/loader/applicator were defined based on common application methods used for antimicrobial pesticides. Note that there were, however, a few deficiencies in this study particularly with respect to quality. [Refer within to Section (6) Data Gaps, Uncertainties and Limitations.]

Exposure results from the CMA study seem to indicate that dermal exposure is the primary exposure route for the seven antimicrobial chemicals analyzed. Inhalation exposures in the CMA data were very low, usually below the chemical limit of detection. Therefore, the data in the CMA study might not be a valid estimation of inhalation exposure for zinc pyrithione.

(ii) <u>Pesticide Handlers Exposure Database (PHED) Data</u>

The *Pesticide Handlers Exposure Database (PHED) Version 1.1* was used to estimate exposures for the following primary residential handlers using antifoulant paints (Table 6), and secondary occupational/secondary residential handler scenarios (Tables 8 and 9) for materials preservatives:

Primary Residential Handlers

(Table 6) Handling zinc pyrithione-containing antifoulant paints using a paint brush; and

(Table 6) Handling zinc pyrithione-containing antifoulant paints using an airless sprayer.

Secondary Occupational/Residential Handlers

(4a, 5a) Handling zinc pyrithione-containing paint end products using a paint brush application method;

[2] These guideline have been superceded by Series 875.1000-875.1600 of the Pesticide Assessment Guidelines.

(4b, 5b)	Handling zinc pyrithione-containing paint end products using an airless sprayer application method; and
(4c, 5c)	Handling zinc pyrithione-containing paint end products using an aerosol spray can application method.

PHED was designed by a task force consisting of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide Regulation, and member companies of the American Crop Protection Association (PHED, 1997). PHED is a generic database containing measured exposure data for workers involved in the handling or application of pesticides under actual field conditions, in primarily agricultural settings. Currently, the database contains values for over 1,700 monitored exposure events (i.e., replicates). The basic assumption underlying the system is that exposure to pesticide handlers can be calculated using the monitored data because exposure is primarily a function of the physical parameters of the handling and application process (i.e., the pesticide use scenario based on the packaging type, application method, and any protective clothing worn). PHED also contains algorithms that allow the user to complete surrogate, task-based exposure assessments beginning with one of the four main data files contained in the system (i.e., mixer/loader, applicator, flagger, and mixer/loader/applicator).

Users can select data from each major PHED file and construct exposure scenarios that are representative of the use of the chemical. The subsetting algorithms in PHED are based on the central assumption that one magnitude of handler exposures to pesticides are primarily a function of activity, formulation type, application method, and clothing scenario. However, to add consistency to the risk assessment process, the EPA, in conjunction with the PHED Task Force, has evaluated all data within the system and developed surrogate exposure tables that contain a series of standard unit exposure values for various exposure scenarios. These standard unit exposure values are based on the “best fit” values calculated by PHED. PHED calculates “best fit” exposure values by assessing the distributions of exposures for each body part included in data sets selected for the assessment (i.e., chest or forearm) and then calculating a composite exposure value representing the entire body. PHED categorizes distributions as normal, lognormal, or in any “other” category. Generally, most data contained in PHED are lognormally distributed or fall into the PHED “other” distribution category. If the distribution is lognormal, the geometric mean for the distribution is used as the “best fit” exposure value. If the data are an “other” distribution, the median value of the data set is used in the calculation of the “best fit” exposure value. As a result, the surrogate unit exposure values that serve as the basis for this assessment generally range from the geometric mean to the median of the selected data set. PHED unit exposure data used in this assessment represent the estimated level of exposure expected per unit amount of pesticide handled and are reported in units of mg exposure/lbs ai handled (PHED, 1998).

PHED has long been used as a surrogate for handler exposure assessment. The data for PHED may have some advantages to CMA data in that they are generally rated as grades A,B,C, so it tends to have better quality QA/QC (i.e., better field, lab and storage stability recoveries), more replicates (i.e., over 15 replicates), less variability (i.e., lower CVs), and reportable inhalation unit exposure values.Data confidence refers to both the "quality" and the "amount" of data for each PHED run. Each study in PHED has been graded from "A" to "E" according to certain Quality Assurance/Quality Control (QA/QC) factors (PHED, 1998).

The confidence levels for the unit exposures are Grade C for paintbrush, Grades B and C for airless spraying, and Grades A and B for aerosol can.

(iii) Residential Exposure Assessment Standard Operating Procedures (SOPs)

The residential exposure assessment SOPs are designed for use in assessing exposure to pesticides in residential settings. The objective of these SOPs is to provide standard default methods for developing residential exposure assessments for both handler and postapplication exposures when chemical- and/or site-specific field data are limited. These methods may be used in the absence of, or as a supplement to, chemical- and/or site-specific data. The SOPs were prepared by EPA's Office of Pesticide Programs, Health Effects Division and Antimicrobials Division with input from EPA's Office of Pollution Prevention and Toxics, and Office of Research and Development (U.S. EPA, 1997a).

For the residential handler exposure assessment, dermal and inhalation exposure data are from the residential SOPs developed using PHED Version 1.1. The values of the residential PHED data versus the occupational PHED data generally differ because the baseline attire is different. The baseline residential clothing attire is short pants, short-sleeve shirt, socks, shoes, and no gloves. The occupational baseline scenario generally represents a handler wearing a long-sleeved shirt, long pants, socks, and shoes with no respirator or chemical-resistant gloves. The grading scheme for the residential PHED data is described in the occupational section. The confidence levels of paintbrush, airless sprayer, and aerosol can are Grade C for paintbrush, Grades B and C for airless spraying, and Grades A and B for aerosol can.

(iv) Literature Study – Garrod et al. (2000)

The Garrod et al (2000) study was identified by the registrant during the 30-day error comment period of the Reregistration Eligibility Decision (RED) process for Zinc Pyrithione (i.e., zinc omadine®). The Garrod et al (2000) study was reviewed by the Antimicrobials Division (AD) to provide dermal and inhalation unit exposures (UEs) appropriate for use in developing antifoulant and wood preservative outdoor painting exposure scenarios for amateur (consumer) applicators. The antifoulant paint in this study was applied using a paint brush and roller to boat hulls of recreational craft stored on sling/cradle/trailers. The scenario monitored in this study (i.e., antifoulant applications via brush/roller) is more representative for Do-It-Yourself (DIY) painters than the surrogate data available in the Pesticide Handlers Exposure Database (PHED). The surrogate data in PHED are based on an indoor painting scenario where latex paint containing a fungicide is applied to interior bathroom walls with a brush. However, only the air concentration data are available from Garrod et al (2000). The dermal portion of the study monitored mostly exposure on the outside of clothing and only one patch was used underneath clothing. New studies measuring both dermal and inhalation exposures are recommended. QA/QC samples consisted of laboratory recoveries. The laboratory recovery results were mostly in the 90 percent range. No replicates were corrected for recovery. The article did not mention field fortifications or storage stability samples (nor did it discuss shipment or storage of field samples).

(b) Estimated Amount Handled

(i) Antifoulants

The estimated amounts handled per day were used in conjunction with data from PHED to calculate exposure dose estimates for residential handler scenarios. Based on review of the existing labels, the residential assessment for antifoulants is based on two products. EPA Reg. No. 64684-4 has been selected because it specifically lists recreational use, is formulated at 4.8 percent (~ 5% a.i.), and does not prohibit spraying. EPA Reg. No. 2693-194 is also included because of the high concentration (47.04 percent diluted as a two part mixture) and there are no label restrictions. Recreational boat owners have several techniques they can use to paint their hulls including paint brush, roller, and airless sprayer. There are no chemical-specific exposure data to assess these techniques. However, surrogate data are available for painting with a brush and an airless sprayer. The surrogate data are based on PHED data for painters wearing long pants, long sleeve shirts, no gloves, and no respirator. The test subjects were painting a bathroom with a paint brush and staining the outside of a house with an airless sprayer. The dermal and inhalation exposures from these techniques have been normalized by the amount of active ingredient handled and reported as PHED *unit exposures (UE)* expressed as mg/lb ai handled. Although the exposures while painting a boat hull may differ slightly, the data are judged to be representative of painting and are used in this assessment. The data from Garrod et al. (2000) were also used as a comparison to PHED because the Garrod (2000) study design is more representative of the use (i.e., painting boat hulls using an antifoulant paint). The air concentration data from Garrod (2000) are used to present the inhalation route-specific risks in normalized units of mg/m^3.

The amount of antifouling paint handled by a do-it-yourself (DIY) boat hull painter is determined by the size of the hull painted. Based on label directions, one gallon of the antifouling paint covers roughly 300 ft^2 with a minimum of 3 coats applied. The antifouling paint in label 64684-4 contains 4.8 percent ai and assuming one gallon of paint weighs ~10 lbs/gallon this corresponds to 0.48 lb ai/gallon. Label 2693-194 is a two part mixture with the Activator portion consisting of 47.04 percent ai. One pint of Activator is mixed with 7 pints of paint. Thus, the final paint mixture consists of 0.588 lb ai/gallon (1.25 lb per pint/gallon paint x 0.4704 ai = 0.588 lb ai/gallon). Various size boats can be potentially painted and this assessment presents a range of boats. There are no label restrictions on the drying time between coats of paint, and therefore, it is assumed that the recommended number of coats of paint can be applied in one day. Refinements to the amount handled on a daily basis can be made if drying times are in the range of 24-hours. The range of boats and amounts of ai handled are listed below:

- **14 ft Boat -** The surface area of the hull of a 14 ft boat with a 5 ft beam is ~70 ft^2 which corresponds to 0.336 lb ai handled for label 64684-4 (i.e., ((70 ft^2 x 3 coats)/300 ft^2 per gallon) x 0.48 lb ai/gallon) and 0.4116 lb ai for label 2693-194 (i.e., ((70 ft^2 x 3 coats)/300 ft^2 per gallon) x 0.588 lb ai/gallon). It is also estimated that it would require ~2 hours to paint 3 coats.

- **20 ft Boat -** The surface area of the hull of a 20 ft boat with a 8 ft beam is ~160 ft^2 which corresponds to 0.768 lb ai handled for label 64684-4 (i.e., ((160 ft^2 x 3 coats)/300 ft^2 per gallon) x 0.48 lb ai/gallon) and 0.9408 lb ai for label 2693-194 (i.e., ((160 ft^2 x 3 coats)/300 ft^2 per gallon) x 0.588 lb ai/gallon). It is also estimated that it would require ~4 hours to paint 3 coats.

- **30 ft Boat -** The surface area of the hull of a 30 ft boat with a 10 ft beam is ~300 ft^2 which corresponds to 1.44 lb ai handled for label 64684-4 (i.e., ((300 ft^2 x 3 coats)/300 ft^2 per gallon) x 0.48 lb ai/gallon) and 1.764 lb ai for label 2693-194 (i.e., ((300 ft^2 x 3 coats)/300 ft^2 per gallon) x 0.588 lb ai/gallon). It is also estimated that it would require ~6 hours to paint 3 coats.

(ii) Materials Preservatives

The estimated amounts handled per day were used in conjunction with data from PHED, the residential SOPs, or CMA to calculate exposure dose estimates for handlers in various scenarios. The estimates of amount handled during manufacturing are 10,000 pounds of slurry and 1,000 gallons of paint. These estimates are based on Agency standard values for industrial practices and were used for all preservatives and paints (density of 10 lb/gal). For industrial laundry treatments an estimate of 10,000 pounds of fabric/textiles are treated per day (based on large-scale commercial operations using high-capacity washer/extractors or continuous batch tunnel washer systems) with zinc pyrithione incorporated during the laundry sour operation. During laundering operations the "sour" acts as a neutralizing agent to lower pH and reduce residual alkalinity in laundered textiles. According to the registrant, the "acid sour" can be made in 1,000 gallon batches and held as a stock solution for use within a few days or weeks depending on the volume of fabrics/textiles treated.

Assumptions for secondary occupational handlers use of paint for brushing (5 gallons) and airless spraying (50 gallons) are also consistent with Agency standard values used in previous assessments. Assumed amounts for the secondary residential handlers use of paint for brushing (2 gallons), airless spraying (15 gallons), and aerosol can (three 12-oz cans) are consistent with the Residential SOPs (EPA, 1997a, 2001). Table 5 provides the estimates used to calculate the amount of zinc pyrithione handled for each exposure scenario.

Note that the exposure scenarios developed for the secondary occupational handlers differ from the secondary residential handlers in terms of the amount of product handled per day and in the data used. The PHED data from the residential SOPs assumes that handlers may wear short pants, short-sleeved shirt, socks, and shoes. The occupational PHED data generally represents a handler wearing a long-sleeved shirt, long pants, socks, and shoes.

Table 5. Exposure Estimates/Assumptions for Amount of Zinc Pyrithione Handled Per Day	
Exposure Scenario	**Scenario Description**
Primary Occupational Handler	
General Preservative Uses: Dry Film, In Can, and Materials Preservation	
(1a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	Assumes treatment per day of 10,000 pounds of slurry used for various manufactured substrates (e.g., food/non-food contact adhesives, caulks/sealants, grouts/patching compounds, processed rubber, textiles, thermoplastic resin-based articles (e.g. air ducts), and food/non-food contact polymeric systems; including repeat-use polymeric food contact materials such as food processing equipment and conveyor belts). EPA Reg. 1258-841 (48 % a.i.) indicates that the maximum application rate is *10,000 ppm* (10 lb/1,000 lbs) to caulk/sealants or 5 lb ai/1,000 lbs (10 lb x .48 (48%) = 4.8 lb ai ~ 5 lb ai).
(1b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	
(1c) Mixing/loading/applying powder pesticide concentrates using open pour methods	Assumes treatment per day of 10,000 pounds of slurry used for various manufactured substrates (e.g., food/non-food contact adhesives, caulks/sealants, grouts/patching compounds, processed rubber, textiles, thermoplastic resin-based articles (e.g. air ducts), and food/non-food contact polymeric systems; including repeat-use polymeric food contact materials such as food processing equipment and conveyor belts). EPA Reg. 1258-840 (95 % a.i.) indicates that the maximum application rate is *5,000 ppm* (5 lb/1000 lbs) to caulk/sealants or 5 lb ai/1,000 lbs (5 lb x .95 (95%) = 4.75 lb ai ~ 5 lb ai).
(1d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	
Paints: Dry Film Preservation	
(2a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	Assumes 1,000 gallons of paint are manufactured per day. EPA Reg. 1258-841 (48 % a.i.) indicates that the maximum application rate is *10,000 ppm* (10 lb/1,000 lbs) to paints or 5 lb ai/1,000 lbs (10 lb x .48 (48%) = 4.8 lb ai ~ 5 lb ai/100 gals at 10 lbs/gal density).
(2b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	
(2c) Mixing/loading/applying powder pesticide concentrates using open pour methods	Assumes 1,000 gallons of paint are manufactured per day. EPA Reg. 1258-840 (95 % a.i.) indicates that the maximum application rate is *5,000 ppm* (5 lb/1,000 lbs) to paints or 5 lb ai/1,000 lbs (5 lb x .95 (95%) = 4.75 lb ai ~ 5 lb ai/100 gals at 10 lbs/gal density).
(2d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	
Fabrics/Textiles: Laundering Treatment for Materials Preservation	

Table 5. Exposure Estimates/Assumptions for Amount of Zinc Pyrithione Handled Per Day

Exposure Scenario	Scenario Description
(3a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	Assumes 10,000 pounds of fabric/textiles are treated per day as a high-end maximum for large commercial operations. EPA 1258-841 (48 % a.i.) indicates that the maximum application rate is *112 ppm* (18 ounces or 1.125 lbs added to the "acid sour" operation to treat 1,000 lbs of fabric), or 0.54 lb ai/1,000 lbs (18 ounces x 1 lb /16 oz ounces x 0.48 (48%) = 0.54 lb ai/1,000 lbs dry weight of fabric.
(3b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	
(3c) Mixing/loading/applying powder pesticide concentrates using open pour methods	Assumes 10,000 pounds of fabric/textiles are treated per day as a high-end maximum for large commercial operations. EPA 1258-840 (95 % a.i.) indicates that the maximum application rate is *56 ppm (* 9 ounces or 0.5625 lbs added to the "acid sour" operation to treat 1,000 lbs of fabric), or 0.534375 lb ai/1,000 lbs (9 ounces x 1 lb/16 ounces x 0.95 (95%) = ~0.54 lb ai/1,000 lbs dry weight of fabric.
(3d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	
Secondary Occupational Handler	
(4a) Handling zinc pyrithione-containing paint end products using a paint brush application method	Assumes 5 gallons or 50 pounds of paint are used per day for occupational scenario. Approximately 5 lb ai are added per 1,000 lbs (100 gallons) of paint.
(4b) Handling zinc pyrithione-containing paint end products using an airless sprayer application method	Assumes 50 gallons or 500 pounds of paint are used per day for occupational scenario. Approximately 5 lb ai are added per 1,000 lbs (100 gallons) of paint.
(4c) Handling zinc pyrithione-containing paint end products using an aerosol spray can application method	Assumes 0.28 gal/day (three 12-oz cans) are used per day for occupational scenario. Approximately 5 lb ai are added per 1,000 lbs (100 gallons) of paint.
Secondary Residential Handler	
(5a) Handling zinc pyrithione-containing paint end products using a paint brush application method	Assumes 2 gallons of paint are used per day for residential scenario. Approximately 5 lb ai are added per 1,000 lbs (100 gallons) of paint.
(5b) Handling zinc pyrithione-containing paint end products using an airless sprayer application method	Assumes 15 gallons of paint are used per day for residential scenario. Approximately 5 lb ai are added per 1,000 lbs (100 gallons) of paint.
(5c) Handling zinc pyrithione-containing paint end products using an aerosol spray can application method	Assumes 0.28 gal/day (three 12-oz cans) are used per day for residential scenario. Approximately 5 lb ai are added per 1,000 lbs (100 gallons) of paint.

(3) Handler Risk Assessment and Characterization

(a) Handler Exposure and Non-Cancer Risk Calculations

Handler exposure assessments are completed by EPA using a baseline exposure scenario and, if required, increasing levels of risk mitigation [personal protective equipment (PPE) and engineering controls] to achieve an appropriate margin of exposure (MOE) or non-cancer risk for occupationally exposed workers only. The baseline scenario generally represents a handler wearing a long-sleeved shirt, long pants, socks, and shoes with no respirator or chemical-resistant gloves. PPE scenarios generally represent handlers wearing one or more of the following PPE: double layer clothing, chemical-resistant gloves, and/or a respirator. Engineering controls generally represent the use of closed systems for mixing/loading/applying.

(i) Antifoulants

Table 6 presents the estimated dermal and inhalation exposures and MOEs. The clothing scenarios presented are based on DIY wearing long pants, long sleeved shirts, no gloves, and no respirator.

Table 6. Exposure and MOEs for Do-it-yourself Boat Hull Painters

Scenario	Boat Size [a]	Amount (Lb ai) [b]	Unit Exposure (mg/lb ai)[c]		Dermal Dose[d] (mg/kg/day)	Inhalation Dose[e] (mg/kg/day)	Dermal MOE [f] Target MOE ≥300	Inhalation MOE [g] Target MOE ≥300
			Dermal	Inhalation				
EPA Reg. No. 64684-4 (4.8 percent ai) All Estimates Based on 3 Coats of Paint in One Day								
Brush (PHED)	14ft x 5 ft	0.336	180	0.28	0.03	0.0013	**17**	**97**
	20ft x 8 ft	0.768			0.07	0.0031	**7**	**42**
	30ft x 10ft	1.44			0.13	0.0058	**4**	**23**
Brush & roller (Garrod et al. 2000)	14ft x 5 ft	0.336	NA	0.00087 (mg/m^3/%ai)	NA	2 hrs painting	NA	**140**
	20ft x 8 ft	0.768				4 hrs painting		**72**
	30ft x 10ft	1.44				6 hrs painting		**48**
Airless	14ft x 5 ft	0.336	38	0.83	0.0064	0.0040	**78**	**33**
	20ft x 8 ft	0.768			0.015	0.0091	**33**	**14**
	30ft x 10ft	1.44			0.03	0.017	**17**	**8**
EPA Reg. No. 2693-194 (47 percent ai) All Estimates Based on 3 Coats of Paint in One Day								
Brush	14ft x 5 ft	0.4116	180	0.28	0.04	0.0017	**13**	**79**
	20ft x 8 ft	0.9408			0.085	0.0038	**6**	**35**
	30ft x 10ft	1.764			0.16	0.0071	**3**	**18**
Brush & roller (Garrod et al. 2000)	14ft x 5 ft	0.4116	NA	0.00087 (mg/m^3/%ai)	NA	2 hrs painting	NA	**15**
	20ft x 8 ft	0.9408				4 hrs painting		**7**
	30ft x 10ft	1.764				6 hrs painting		**5**
Airless	14ft x 5 ft	0.4116	38	0.83	0.008	0.0049	**63**	**27**
	20ft x 8 ft	0.9408			0.02	0.011	**25**	**12**
	30ft x 10ft	1.764			0.033	0.021	**15**	**6**

Bold indicates MOE exceeds level of concern (i.e., MOE less than target MOE of 300).
a Hull area for various size boats assumes that the dimension of the hull's painted surface area is roughly based on length and width.
b Amount handled based on the label (300ft^2/gallon, 3 coats, % ai, 10 lb/gal density of paint).
c Unit exposures based on PHED data for painters wearing long pants, long sleeve shirt, no gloves, and no respirator. The inhalation UE from Garrod et al (2000) is normalized by the percent of ai in the paint.
d Dermal Dose (mg/kg/day) = dermal UE (mg/lbai) x amount handled (lb ai) x dermal absorption factor (3%) x 1/60 kg BW.

e Inhalation Dose (mg/kg/day) = inhalation UE (mg/lbai) x amount handled (lb ai) x 1/70 kg BW.

f Dermal MOE = Developmental NOAEL of 0.5 mg/kg/day / Dermal dose (mg/kg/day).

g Inhalation MOE = NOAEL 0.13 mg/kg/day / Inhalation dose (mg/kg/day) or the route-specific inhalation MOE = (0.5 mg/m^3 x 6 hrs/day animal) / [(paint air conc mg/m^3/% ai x % ai in paint x hrs painting) x (1 m^3 work breathing rate / 0.4 m^3 resting breathing rate)].See Equation 4a. Note: The route-specific inhalation MOEs do not coincide with the route-extrapolation inhalation MOEs because of the differences in methodologies (e.g., UE, dose vs air conc, estimates of hours painting versus amount of ai handled).

The estimated dermal and inhalation MOEs are of concern for most of boat sizes when using a paint brush. For the airless sprayers the dermal MOEs are not of concern (i.e. are greater than 300) for a 14ft boat but are of concern for the larger boats. For all boat sizes, all of the inhalation MOEs are below the target MOE of 300. The majority of the painting exposure is attributed to the hands and all of the dermal MOEs would not be of concern if painters wore chemical resistant gloves.

(ii) Materials Preservatives

Exposure estimates for primary occupational handlers are presented in Table 7. The CMA study data were considered more appropriate than PHED data for best characterizing the antimicrobial uses of zinc pyrithione in industrial manufacturing settings. The CMA study provides two risk mitigation methods (open pouring of liquid/solid using gloves and pump metering liquid using gloves). These two risk mitigation methods are both reported in Table 7. It should be noted that no adjustments were made to the baseline CMA exposure values to reflect use of additional PPE (i.e., respirators). It is not standard Agency practice to apply protection factors to baseline CMA exposure values to estimate doses adjusted for use of additional PPE in scenarios where the actual CMA data were not generated using such PPE.

The CMA study does not assess paint application methods/exposure doses. Therefore, the PHED database is used to assess dermal and inhalation exposures to secondary handlers applying paint end products containing zinc pyrithione, using a paint brush, airless sprayer, and aerosol can. Table 8 presents the exposure/risk calculations at baseline for secondary occupational handlers. In addition to the baseline calculations for the airless spray painting scenario, MOEs are calculated for PPE protection using gloves and an organic vapor respirator. Also, glove PPE was included for the paint brush scenario. Table 9 presents the exposure/risk calculations at baseline for secondary residential handlers using PHED data reported in the residential SOPs (U.S. EPA, 1997) for the painting scenarios. It is not current Agency policy to evaluate PPE for residential uses. For the painting scenarios in Table 8 for occupational handlers, the PHED database allows for the calculation of unit exposures at both baseline and with the addition of PPE by applying a protection factor of 90% to baseline values for chemical-resistant gloves and/or organic respirator in scenarios where the actual PHED data were not generated using such PPE.

Although the secondary occupational handler assessments include PPE considerations, the mandatory use of PPE by handlers for non-spray applications of paint (i.e., paint brush) is not considered a viable protective measure due to probable non-compliance among paint handlers even if the zinc pyrithione-treated paint end products have labeling requiring the use of PPE. However, the Agency assumes that PPE use compliance would be viable for the spray painting scenarios, specifically airless sprayer applications that would result in the greatest potential for inhaled particulate without the use of a dust/mist or organic vapor respirator.

Table 7. Estimates of Exposures and Risks to Primary Occupational Handlers of Zinc Pyrithione									
Application Scenario[a]	**Unit Exposure[b] (mg/lb ai)**		**Use Rate (lb ai/1000 lb, or lb ai/100 gal)[c]**	**Amount Handled (lb/day or gal/day)[d]**	**Body Weight (kg)**	**Dermal Dose (mg/kg/day)[e]**	**Inhalation Dose (mg/kg/day)[f]**	**Dermal MOE[g] Target MOE ≥100**	**Inhalation MOE[h] Target MOE ≥100**
	Dermal	**Inhalation**							
General Preservatives Uses: Dry Film, In Can, and Material Preservation									
(1a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	0.135	0.00346	5 lb ai/1,000 lb	10,000 lb/day	60 (dermal) 70 (inhalation)	0.0034	2.47E-3	147	**53**
(1b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	0.00629	0.000403				0.00016	2.88E-4	3125	452
(1c) Mixing/loading/applying powder pesticide concentrates using open pour methods	0.466	0.0119				0.012	8.50E-3	**42**	**15**
(1d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	0.00629	0.000403				0.00016	2.88E-4	3125	452
Paints: Dry Film Preservation									

Table 7. Estimates of Exposures and Risks to Primary Occupational Handlers of Zinc Pyrithione									
Application Scenario[a]	Unit Exposure[b] (mg/lb ai)		Use Rate (lb ai/1000 lb, or lb ai/100 gal)[c]	Amount Handled (lb/day or gal/day)[d]	Body Weight (kg)	Dermal Dose (mg/kg/day)[e]	Inhalation Dose (mg/kg/day)[f]	Dermal MOE[g] Target MOE ≥100	Inhalation MOE[h] Target MOE ≥100
	Dermal	Inhalation							
(2a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	0.135	0.00346	5 lb ai/100 gal	1,000 gal	60 (dermal) 70 (inhalation)	0.0034	2.47E-3	147	**53**
(2b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	0.00629	0.000403				0.00016	2.88E-4	3125	452
(2c) Mixing/loading/applying powder pesticide concentrates using open pour methods	0.466	0.0119				0.012	8.50E-3	**42**	**15**
(2d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	0.00629	0.000403				0.00016	2.88E-4	3125	452
Fabrics/Textiles: Laundering Treatment for Material Preservation									
(3a) Mixing/loading/applying liquid pesticide concentrates using open pour methods	0.135	0.00346	0.54 lb ai/1,000 lb	10,000 lb	60 (dermal) 70 (inhalation)	3.65E-4	2.67E-4	1,370	487
(3b) Mixing/loading/applying liquid pesticide concentrates using metering equipment (pump liquid)	0.00629	0.000403				1.7E-5	3.11E-5	29,412	4,180
(3c) Mixing/loading/applying powder pesticide concentrates using open pour methods	0.466	0.0119				1.26E-3	9.18E-4	397	142

Table 7. Estimates of Exposures and Risks to Primary Occupational Handlers of Zinc Pyrithione									
Application Scenario[a]	Unit Exposure[b] (mg/lb ai)		Use Rate (lb ai/1000 lb, or lb ai/100 gal)[c]	Amount Handled (lb/day or gal/day)[d]	Body Weight (kg)	Dermal Dose (mg/kg/day)[e]	Inhalation Dose (mg/kg/day)[f]	Dermal MOE[g] Target MOE ≥100	Inhalation MOE[h] Target MOE ≥100
	Dermal	Inhalation							
(3d) Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques)	0.00629	0.000403				1.7E-5	3.11E-5	29,412	4,180

Footnotes:

a Scenarios based on use patterns described on labels and LUIS report. Primary occupational handlers include people who add zinc pyrithione as a general preservative to products such as food/non-food contact adhesives; floor tile adhesives; caulks and sealants; grout and patching compounds; food/non-food contact polymeric materials; rubber and thermoplastic resins; preservatives in latex paint; architectural coatings; dry film preservative in products such as dry wall and building materials; and laundered fabrics.

b Unit exposures based on CMA data for inhalation and dermal exposure. Data represent single layer clothing and gloves. No respirator worn.

c Represents the maximum use rates on the registered zinc pyrithione product labels; EPA Registration Nos.: 1258-840 and 1258-841.

d Standard EPA default assumptions: 10,000 for caulk; 1,000 for paint; and 1,000 for laundered fabric.

e Dermal Dose (mg/kg/day) = [Unit Dermal Exposure (mg/lb ai) * Use Rate (lb ai/lb product or lb ai/gal product) * Amount Handled per Day (lb product/day) * Dermal Absorption Factor (3%)]/ Body Weight (60 kg based on selection of a developmental endpoint).

f Inhalation Dose (mg/kg/day) = [Unit Inhalation Exposure (mg/lb ai) * Use Rate (lb ai/lb product or lb ai/gal product) * Amount Handled per Day (lb product/day)] / Body Weight (70 kg).

g Dermal MOE = Developmental NOAEL (mg/kg/day) / Dermal Dose (mg/kg/day). Where the developmental NOAEL is 0.5 mg/kg/day.

h Inhalation MOE = Inhalation NOAEL (mg/kg/day) / Inhalation Dose (mg/kg/day). Where the inhalation NOAEL of 0.0005 mg/L/day is converted to 0.13 mg/kg/day.

Table 8. Estimates of Exposures and Risks to Secondary Occupational Handlers of Zinc Pyrithione									
Application Scenario[a]	Unit Exposure (mg/lb ai)[b]		Use Rate (Lb ai/1,000 lb or lb ai/100 gal)[c]	Amount Handled (lb/day or gal/day)[d]	Body Weight (kg)	Dermal Dose (mg/kg/day)[e]	Inhalation Dose (mg/kg/day)[f]	Dermal MOE[g] Target MOE ≥100	Inhalation MOE[h] Target MOE ≥100
	Dermal	Inhalation							
Paints Containing Zinc Pyrithione									

Table 8. Estimates of Exposures and Risks to Secondary Occupational Handlers of Zinc Pyrithione									
Application Scenario[a]	**Unit Exposure (mg/lb ai)[b]**		**Use Rate (Lb ai/1,000 lb or lb ai/100 gal)[c]**	**Amount Handled (lb/day or gal/day)[d]**	**Body Weight (kg)**	**Dermal Dose (mg/kg/day)[e]**	**Inhalation Dose (mg/kg/day)[f]**	**Dermal MOE[g] Target MOE $\geq$100**	**Inhalation MOE[h] Target MOE $\geq$100**
	Dermal	**Inhalation**							
(4a) Handling zinc pyrithione-containing paint end products using a paint brush application method	180	0.28	5 lb ai/100 gal	5 gal/day	60 (dermal) 70 (inhalation)	0.0225	1.0E-3	**22**	130
	24* (PPE)					0.003* (PPE)		167	
(4b) Handling zinc pyrithione-containing paint end products using an airless sprayer application method	38	0.83		50 gal/day		0.0475	0.030	**11**	4
	14* (PPE)	0.083** (PPE)				0.0175* (PPE)	0.003** (PPE)	**29** (PPE)	**44** (PPE)
(4c) Handling zinc pyrithione-containing paint end products using an aerosol spray can application method	190	1.3		0.28 gal/day (3 12-oz cans)		1.33E-3	2.60E-4	376	500

Footnotes:

[a] Scenarios based on use patterns described on labels and LUIS report. Secondary occupational handlers include persons who apply products containing zinc pyrithione incorporated as a general preservative (e.g., floor tile adhesives, caulks/sealants, grout/patching materials, and rubber/thermoplastic resin/polymeric-based products), and persons who apply latex paint, architectural paints and coatings, or dry wall and building materials that contain zinc pyrithione.

[b] Dermal unit exposures based on data from PHED, Version 1.1 (single layer clothing; long-sleeved shirt, long pants; no gloves). Unit exposure values for inhalation based on data from PHED, Version 1.1 and assumes no respirator worn. * Use of gloves as PPE assumes a 90% protection factor. ** Use of organic vapor respirator as PPE assumes a 90% protection factor.

[c] Represents the maximum use rates on the registered zinc pyrithione product labels; EPA Registration Nos.: 1258-840, 1258-841, and 1258-1183.

[d] Standard EPA default assumptions.

[e] Dermal Dose (mg/kg/day) = [Unit Dermal Exposure (mg/lb ai) * Use Rate (lb ai/lb product or lb ai/gal product) * Amount Handled per Day (lb product/day) * Dermal Absorption Factor (3%)] / Body Weight (60 kg based on selection of a developmental endpoint).

[f] Inhalation Dose (mg/kg/day) = [Unit Inhalation Exposure (mg/lb ai) * Use Rate (lb ai/lb product or lb ai/gal product) * Amount Handled per Day (lb product/day)] / Body Weight (70 kg).

[g] Dermal MOE = Developmental NOAEL (mg/kg/day) / Dermal Dose (mg/kg/day). Where the developmental NOAEL is 0.5 mg/kg/day.

[h] Inhalation MOE = Inhalation NOAEL (mg/kg/day) / Inhalation Dose (mg/kg/day). Where the inhalation NOAEL of 0.0005 mg/L/day is converted to 0.13 mg/kg/day.

Table 9. Estimates of Exposures and Risks to Secondary Residential Handlers of Zinc Pyrithione									
Scenario[a]	Unit Exposure (mg/lb ai)[b]		Use Rate (Lb ai/1,000 lb or lb ai/100 gal)[c]	Amount Handled (lb/day or gal/day)[d]	Body Weight (kg)	Dermal Dose (mg/kg/day)[e]	Inhalation Dose (mg/kg/day)[f]	Dermal MOE[g] Acceptable MOE ≥300	Inhalation MOE[h] Acceptable MOE ≥300
	Dermal	Inhalation							
Paints Containing Zinc Pyrithione									
(5a) Handling zinc pyrithione-containing paint end products using a paint brush application method	230	0.28	5 lb ai/100 gal	2 gal/day	60 (dermal) 70 (inhalation)	0.0115	4.0E-4	**44**	325
(5b) Handling zinc pyrithione-containing paint end products using an airless sprayer application method	79	0.83		15 gal/day		0.030	8.89E-3	**17**	**15**
(5c) Handling zinc pyrithione-containing paint end products using an aerosol spray can application method	220	2.4		0.28 gal/day (3 12-oz cans)		1.54E-3	4.80E-4	325	**271**

Footnotes:

[a] Scenarios based on use patterns described on labels and LUIS report. Secondary residential handlers include homeowners who apply products containing zinc pyrithione incorporated as a general preservative (e.g., floor tile adhesives, caulks/sealants, grout/patching materials, and rubber/thermoplastic resin/polymeric-based products), and homeowners who apply latex paint, architectural coating, and dry wall and building materials that contain zinc pyrithione.

[b] Dermal unit exposures based on data from PHED, Version 1.1 (single layer clothing; short-sleeved shirt, short pants; no gloves). Unit exposure values for inhalation based on data from PHED, Version 1.1 and assumes no respirator worn. * Use of gloves as PPE assumes a 90% protection factor. ** Use of organic vapor respirator as PPE assumes a 90% protection factor.

[c] Represents the range of use rates in the zinc pyrithione labels; EPA registration Numbers 1258-840 and 1258-841.

[d] Standard EPA default assumptions.

[e] Dermal Dose (mg/kg/day) = [Unit Dermal Exposure (mg/lb ai) * Use Rate (lb ai/lb product or lb ai/gal product) * Amount Handled per Day (lb product/day) * Dermal Absorption Factor (3%)] / Body Weight (60 kg based on selection of a developmental endpoint).

[f] Inhalation Dose (mg/kg/day) = [Unit Inhalation Exposure (mg/lb ai) * Use Rate (lb ai/lb product or lb ai/gal product) * Amount Handled per Day (lb product/day)] / Body Weight (kg).

[g] Dermal MOE = Developmental NOAEL (mg/kg/day) / Dermal Dose (mg/kg/day). Where the developmental NOAEL is 0.5 mg/kg/day.

[h] Inhalation MOE = Inhalation NOAEL (mg/kg/day) / Inhalation Dose (mg/kg/day). Where the inhalation NOAEL of 0.0005 mg/L/day is converted to 0.13 mg/kg/day.

(i) ***Daily Dermal Dose***

The potential daily dermal doses in Tables 7, 8, and 9 were calculated using the following equation:

Equation 2:

$$Daily\ Dermal\ Dose = Unit\ Exposure\ x\ Use\ Rate\ x\ Amount\ Handled\ x\ Dermal\ Absorption\ Factor\ x \left(\frac{1}{Body\ Weight}\right)$$

where:

Unit Exposure (mg/lb ai)	=	Values obtained from CMA (CMA, 1992), PHED (PHED, 1997), or Residential SOPs (U.S. EPA, 1997a)
Use Rate (lb ai/1000 lb or 1 lb ai/100 gallons)	=	Values from Table 5
Amount Handled (lb/day or gal/day)	=	Values from Table 5
Dermal Absorption Factor (%)	=	3 %
Body Weight (kg)	=	60 kg (based on use of a developmental NOAEL as endpoint for dermal exposure)

(ii) ***Daily Inhalation Dose***

The potential daily inhalation doses shown in Tables 7, 8, and 9 were calculated using the following equation:

Equation 3:

$$Daily\ Inhalation\ Dose = Unit\ Exposure\ x\ Use\ Rate\ x\ Amount\ Handled\ x \left(\frac{1}{Body\ Weight}\right)$$

where:

Unit Exposure (mg /lb ai)	=	Values obtained from CMA (CMA, 1992), PHED (PHED, 1997), or Residential SOPs (U.S. EPA, 1997a).
Use Rate (lb ai/1000 lb or 1 lb ai/100 gallons)	=	Values from Table 5
Amount Handled (lb/day or gal/day)	=	Values from Table 5
Body Weight (kg)	=	70 kg

The calculations of both the daily dermal and inhalation doses of zinc pyrithione received by handlers were used to assess the potential dermal and inhalation risks to handlers. The MOEs were calculated using a developmental NOAEL of 0.5 mg/kg/day and an inhalation NOAEL of 0.13 mg/kg/day, respectively. The following formula describes the calculation of an MOE:

Equation 4:

$$MOE = \frac{NOAEL\left(\frac{mg}{kg / day}\right)}{Daily\ Dose\ (mg / kg / day)}$$

The inhalation route-specific MOEs shown in Table 6 for the antifoulant paint use were calculated using equation 4a. This equation was only used for the antifoulant paints because the inhalation exposure data were available as air concentrations (mg/m^3) for this scenario.

Equation 4a:

$$MOE = \frac{NOAEL\ (mg/m^3)\ x\ D_A}{Inhalation\ Exposure\ Concentration\ (mg/m^3)\ x\ D_H\ x\left(\frac{Human\ MV_{ACTUAL}}{Human\ MV_{REST}}\right)}$$

Where:

NOAEL	=	Inhalation endpoint of concern for zinc pyrithione in (mg/m^3)
D_A	=	Duration of daily animal exposure in study (hrs/day)
Inhal Exp Con	=	Inhalation exposure concentration from Garrod et al (2000) (mg/m^3)
D_H	=	Duration of daily human exposure (hrs/day)
MV_{ACTUAL}	=	Minute Volume for exposure scenario (L/min)
MV_{REST}	=	Minute Volume at rest (L/min)

This equation accounts for the differences in the duration of daily exposure for animals (D_A) and humans (D_H), and the increased respiration and exposure that results from the increased activity (USEPA 1998).

(b) <u>Handler Non-Cancer Risks from Exposure to Zinc Pyrithione</u>

The target MOE is $\geq$100 for occupational handlers and the target MOE is $\geq$ 300 for residential handlers for short-term, intermediate-term, and long-term exposures. The results presented in Tables 7, 8, and 9 are summarized as follows.

(i) <u>Primary Occupational Handler Scenarios with Non-Cancer Dermal and Inhalation Risk Concerns (Short-Term, Intermediate-Term, and Long-Term Risks)</u>

The calculations for dermal risk indicate that MOEs are greater than 100 for most of the primary occupational handler scenarios assessed, except open pouring of the powder formulation for general preservative/paint preservative uses (See Table 7.). In addition, open pouring of liquid and powder concentrates posed inhalation risks of concern (MOEs < 100) at baseline (no respirator). The scenarios are as follows:

- (1a) and (2a) Mixing/loading/applying liquid pesticide concentrates using open pour methods (inhalation MOE = 53); and
- (1c) and (2c) Mixing/loading/applying powder pesticide concentrates using open pour methods (inhalation MOE = 15; dermal MOE = 42).

It should be noted that no adjustments were made to the baseline CMA exposure values to reflect use of additional PPE (i.e., respirators). Also note that the baseline CMA values for the dermal exposures represent workers wearing gloves. It is not standard Agency practice to apply protection factors to baseline CMA exposure values to estimate adjusted doses representing use of additional PPE in scenarios where the actual CMA data were not generated using such PPE. In addition, there are a number of data gaps for many of the scenarios identified.

Data Gaps

Since CMA data are not available for closed loading of powders (i.e., metering systems) CMA data for closed liquid delivery systems (i.e., metered pump liquid) were used as "surrogate" data. There is some uncertainty regarding whether this approach may underestimate potential exposures/risks. Therefore, data gaps exist for the following scenarios:

- (1d),(2d) and (3d): Mixing/loading/applying powder pesticide concentrates using metering equipment (automatic-dispensing techniques).

(ii) Secondary Occupational Handler Scenarios with Non-Cancer Dermal and Inhalation Risk Concerns (Short-Term, Intermediate-Term, and Long-Term Risks)

The calculations of dermal risks indicate that MOEs are less than 100 at **baseline** for the following scenarios (See Table 8):

- (4a) Handling zinc pyrithione-containing paint products (as a material preservative) using a paint brush application method (dermal MOE = 22 without glove PPE); and
- (4b) Handling zinc pyrithione-containing paint products (as a material preservative) using an airless sprayer application method (dermal MOEs = 11 without PPE and 29 with the use of gloves as PPE).

The use of adjusted PHED values to represent use of chemical-resistant gloves in scenario (4a) yielded a dermal risk MOE greater than 100 (MOE = 167), which is not of concern.

The calculations of inhalation risks indicate that MOEs are less than 100 at **baseline** (i.e., no respirator) for the following scenario (See Table 8):

- (4b) Handling zinc pyrithione-containing paint products (as a material preservative) using an airless sprayer application method (inhalation MOE = 4 without PPE).

The calculations of inhalation risks indicate that the MOE is less than 100 even with applied protection factors for **organic vapor respirator PPE** in the following scenario:

- (4b) Handling zinc pyrithione-containing paint products (as a material preservative) using an airless sprayer application method (inhalation MOE = 44 with an organic vapor respirator as PPE).

The MOEs for inhalation risks are not of concern (MOE $\geq$100) for the remaining secondary occupational handler scenarios (i.e., paint brush and aerosol spray can).

(iii) Secondary Residential Handler Scenarios with Non-Cancer Dermal and Inhalation Risk Concerns (Short-Term, Intermediate-Term, and Long-Term Risks)

The calculations of dermal and inhalation risks indicate that MOEs are less than 300 at **baseline** for the following scenarios (See Table 9):

- (5a) Handling zinc pyrithione-containing paint products (as a material preservative) using a paint brush application method (dermal MOE = 44); and
- (5b) Handling zinc pyrithione-containing paint products (as a material preservative) using an airless sprayer application method (dermal MOE = 17; inhalation MOE=15), and
- (5c) Handling zinc pyrithione-containing paint products (as a material preservative) using an aerosol spray can application method (inhalation MOE = 271).

It is not current Agency policy to assume PPE for residential handlers.

(4) Postapplication Exposures and Risks

EPA has determined that there are potential exposure concerns relating to postapplication exposures to zinc pyrithione. There are potential exposures following applications of zinc pyrithione concentrates in industrial settings and zinc pyrithione-treated end-products manufactured for commercial, industrial, and residential use sites. EPA has identified two levels of postapplication exposures: primary and secondary occupational, and secondary residential postapplication exposures. Zinc pyrithione has a low vapor pressure (i.e.,<$1.87x10^{-9}$ torr @ 25°C) and is, therefore, not likely to generate sufficient vapor to cause an inhalation concern to occupational and residential populations performing postapplication tasks, or occupying recently treated areas, or from bystander contact with treated articles. Therefore, postapplication inhalation exposures were not assessed.

(a) Primary Occupational Postapplication Exposures

EPA has identified zinc pyrithione exposure scenarios for primary occupational postapplication exposures in commercial and industrial settings as follows:

- Dermal and inhalation exposures to occupational workers in areas where polymeric materials have been treated with zinc pyrithione during the manufacturing process.
- Dermal and inhalation exposures to occupational workers in areas where paints have been treated with zinc pyrithione during the manufacturing process.
- Dermal and inhalation exposures to occupational workers in areas where adhesives, coatings, emulsions have been treated with zinc pyrithione during the manufacturing process.
- Dermal and inhalation exposures to occupational workers in areas where fabrics have been treated with zinc pyrithione in the manufacturing process.

Postapplication exposures are limited to mists and steams resulting from manufacturing process operations. However, occupational postapplication dermal and inhalation exposures to zinc pyrithione are likely to be minimal compared to handler situations because of dilution of the zinc pyrithione concentrates into manufactured end-use product matrices. Since primary occupational postapplication dermal exposures are likely to be brief and concentrations are expected to be more diluted compared to handler exposures, a risk assessment is not required.

(b) Secondary Occupational Postapplication Exposures

EPA has identified one secondary occupational postapplication exposures scenario in commercial and industrial settings, including both dermal and inhalation exposures. Workers could have dermal and inhalation exposures to zinc pyrithione-treated adhesives, caulks, sealants, and paints. However, this exposure is expected to be minimal, since the paint, and caulks and sealants are likely to dry within one day. Therefore, these scenarios were not quantitatively evaluated. Exposures resulting from contact with treated fabrics/textiles, polymeric materials and related treated substrates are expected to be negligible because of limited transfer of product residues and product dilution.

(c) Residential Postapplication Exposures and Risks

Although EPA-registered zinc pyrithione pesticide product concentrates are not used in residential areas, the manufactured consumer end-products containing zinc pyrithione are used extensively in and around the home. Current labeling for the registered industrial end-use products cites use for incorporation into various manufactured finished goods which adults and children may come into contact with in residential settings. Zinc pyrithione is used for incorporation into articles made from food contact polymers (utensils and storage containers)and for articles made of nonfood contact polymers, styrene butadiene rubber and thermoplastic resins (carpets and other floor coverings, textiles, plastic furniture, home furnishings, housewares, sports equipment, footwear components, mattress liners, air ducts, etc.). Based on the use patterns, EPA has identified exposure scenarios for assessing residential postapplication exposures including:

- Dermal exposures to consumers from products made of polymeric materials containing zinc pyrithione (e.g., shoe sole liners);
- Non-dietary ingestion exposures to children associated with object-to-mouth contact with zinc pyrithione-treated polymeric products (e.g., household furnishings/articles); and
- Non-dietary ingestion exposures to children associated with hand-to-mouth contact with zinc pyrithione-treated polymeric products (e.g., household furnishings/articles).

Zinc pyrithione is used as a microbiostat and mildewcide to control bacterial and mildew growth in articles used as components of heating ventilation and air conditioning (HVAC) systems. Zinc pyrithione (EPA Reg. No. 1258-840 at 95 percent ai, 1258-841 at 48 percent ai, and 1258-1235 at 37.6 percent ai) is impregnated into thermoplastic resins at concentrations up to 4000 ppm. These thermoplastic resins can be incorporated into air filters, air filtration components, air filtration media, and duct work. These end use products are intended for industrial, hospital, residential and commercial HVAC systems.

Postapplication residential dermal exposures are expected to be of minimal concern for treated articles used in HVAC systems since these components are not readily available for dermal contact. Dermal contact with wet paint was not assessed because the paint is expected to dry within a day, so any potential exposure is expected to be negligible. The potential postapplication inhalation exposure from zinc pyrithione treated articles, such as air duct surfaces in HVAC systems, is expected to be minimal based on bounding estimates of saturation concentrations and/or dry aerosols from particles degraded from air duct surfaces. Thus, there are no risk concerns and inhalation postapplication exposures were not quantitatively evaluated.

The Food Quality Protection Act (1996) sets an explicit standard for assessing potential exposures and risks to children/infants and other sensitive sub-populations from contact with pesticide residues. Specifically, FQPA requires EPA to give special consideration to exposure to “ensure that there is a reasonable certainty that no harm will result to infants and children from aggregate exposure to the pesticide chemical residue...” Because of the potential increased susceptibility of infants and children, FQPA requires that EPA evaluate and characterize potential exposure/risk scenarios specific to children/ infants and other sensitive sub-populations in residential settings.

(i) Dermal Exposure to Polymeric Products Incorporated with Preservative (e.g., Shoe Liners)

To calculate dermal exposures to preservatives incorporated into polymeric materials, an exposure assessment entitled "Health Assessment of the Use of Zinc Pyrithione Incorporated Into Polyurethane Sole Liners of Shoes" MRID 441086-01 was used for exposure information (Olin Corporation, 1996). In general, the study was not designed to satisfy any of the requirements (i.e., laboratory, method, and field recoveries, storage stability issues, field fortifications, sufficient replications) of EPA's Series 875.2400 Occupational and Residential Exposure Test Guidelines; therefore, the study does not comply with these guidelines. Review of this study was based solely on issues of technical merit and a discussion of uncertainties and limitations. Leach rate information provided in the FDA Migration Study (MRID 441086-02) was used in conjunction with information in the Exposure Factors Handbook (U.S. EPA, 1997a) to estimate dermal exposure to preservative incorporated in sole liners (U.S. EPA, 2003).

The dermal assessment assumes that 0.4 percent (4,000 ppm) of zinc pyrithione is incorporated into polyurethane. The FDA Migration Study (MRID 441086-02) indicates that 1.5 ppm (0.00015%) of zinc pyrithione leaches out of polyethylene after 10 days using corn oil as a solvent. For this assessment, it is assumed that 1.5 ppm of preservative will leach out from the sole liner and be available for contact. This assessment conservatively assumes that 100 % of the residues available on the surface of the soles are transferred to the skin, and of those residues, only 3% are dermally absorbed for adults (based on use of an oral developmental endpoint for risk assessment), and 100% are dermally absorbed for children. Both feet will be assumed to be exposed.

The Exposure Factors Handbook indicates that the 50th percentile surface area of feet is 1,310 cm^2 for adult males and 1,140 cm^2 for adult females (U.S. EPA, 1997b). Since only the soles of the feet are expected to contact the liners, one half of the surface area of the feet is assumed. The sole liners are expected to be 1 cm thick. The density of polyurethane is close to 1 g/cm^3. Thus, the mass of the sole liners (SL) are expected to be 655 gm for male feet and 570 gm for female feet. An adult body weight of 60 kg was assumed.

For children, the surface area of the feet is 7.1 percent of the total surface area (U.S. EPA, 1997b). The total mean surface area for male and female children ages 3 to 4 is 6,565 cm^2 (U.S. EPA, 1997a). Therefore, the surface area of the feet is 466 cm^2. Since only the soles of the feet are expected to contact the sole liner, one half of the surface area of the feet is assumed to contact the sole liner. The sole liners are expected to be 1 cm thick. The density of polyurethane is close to 1 gm/cm^3. Thus, the mass of the sole liners (SL) is expected to be 233 gm. The body weight used for children (ages 1 to 6) is 15 kg. This scenario was considered to be short-, intermediate and long-term in duration.

The calculation of PDR is as follows:

Equation 5: *PDR* = *[SL x AR x LR x CF x DAF] / [BW]*

where:

PDR	=	Potential dose rate from dermal contact (mg/kg-day)
SL	=	Mass of sole liner (gm)
LR	=	Leach rate. Fraction of preservative leaching out (i.e., 1.5 ppm/4,000 ppm)
AR	=	Application rate is 4,000 ppm. 3.8 mg ai/1,000 mg polymer incorporated into sole liners
CF	=	Conversion factor is 1,000 mg/gm
DAF	=	Dermal Absorption Factor of 3% (applied to adult dermal dose only)
BW	=	The body weight is 60 kg for adults and 15 kg for children.

----- EXPOSURES PREDICTED -----

PDR = 4.06E-4 mg/kg-day adults (female)
4.67E-4 mg/kg-day adults (male)
2.2E-2 mg/kg-day children

The selected NOAEL is divided by the PDR to calculate MOE. A developmental NOAEL of 0.5 mg/kg/day is used for adults and a dermal NOAEL of 100 mg/kg/day was selected for children. The calculated dermal MOEs (1,231 for adult females and 4,500 for toddlers) are greater than the target MOE of 300, and therefore do not exceed the Agency's level of concern. The results of this assessment are presented in Table 10.

(ii) Non-Dietary Oral Exposures from Treated Polymeric Articles (e.g., Home Furnishings)

Incidental ingestion exposures were assessed for a toddler exposed to a representative zinc pyrithione-treated article found in the home (e.g., a plastic storage container). Incidental ingestion exposures were assessed for both hand-to mouth and object-to-mouth scenarios. These exposure scenarios were assumed to be of short- and intermediate-term duration (up to 6 months), since it is assumed that the child may not be in contact with the treated household object for a sustained, long period of time. A detailed analysis of the exposures is presented below. The assessment was conducted using registrant-submitted migration studies (MRIDs 441086-01 and 441086-02) and updated exposure assumptions from the Residential SOPs (2001) including child activity patterns (e.g., frequency of mouthing behaviors). The calculations of the exposure estimates for each scenario are based on a risk analysis conducted for Microban Additive "B" (Triclosan or Irgasan DP 300) (Dang, 1997) which assessed risks to a 12 month old child playing with a "Create-A-Song" toy treated with the antimicrobial.

Non-Dietary Incidental Ingestion of Preservative from Hand-to-Mouth Contact

(1) Exposure Algorithims

Equations 6 and 7 were used to calculate the daily dose for hand-to-mouth incidental ingestion exposure to children handling a treated article (e.g., a plastic storage container). An MOE was calculated using Equation 4.

Equation 6

$$SR = \frac{\%\,A.I.\ x\ W\ x\ CF\ x\ F}{SA}$$

where:

SR	=	Surface residue (mg a.i./cm^2) (0.0075 mg ai/cm2)
% A.I.	=	Percent a.i. in treated article by total weight (%) (0.4%)
W	=	Weight of treated article (g) (50 g)
CF	=	Conversion factor (1,000 mg/g)
F	=	Percent additive available at the surface of the treated article (%) (0.00375% based on MRID 441086-02)
SA	=	Surface area of treated article (cm^2) (500 cm2)

Equation 7

$$PDD = \frac{SR\ x\ F1\ x\ F2\ x\ SA\ x\ FQ\ x\ ED}{BW}$$

where:

PDD	=	Potential daily dose (mg/kg/day) (0.0036 mg/kg/day)
SR	=	Surface residue (mg a.i./cm^2) (0.0075 mg ai/cm2)
F1	=	Fraction residue transferred from treated article to hand (%) (50%)
F2	=	Fraction residue transferred from hand to mouth (%) (50%)
SA	=	Surface area of hands contacting the treated article (cm^2) (20 cm2)
FQ	=	Frequency of mouthing the hands (events per hour) (20 times/hr)
ED	=	Exposure Duration (hr/day) (2 hr)
BW	=	Body weight of a 12 month old child (kg) (10 kg)

(2) Surrogate Exposure Data and Assumptions

The non-dietary ingestion of preservative from Hand-to-Mouth contact uses "surrogate" exposure estimates from Dang, 1997 and data from MRID 441086-01. Chemical-specific leaching data were used to estimate the amount of active ingredient at the surface of the treated article which is available for each handling event using Equation 7. MRID 441086-02 indicates that 1.5 ppm of active ingredient out of 4,000 ppm of zinc pyrithione incorporated into polyethylene, leached out under conditions of elevated temperatures and 10 days of extraction (i.e., 0.00375% per day). This exposure estimate is based on the assumption that for each handling event, diffusion of the active ingredient available at the surface to the child's hands is allowed to reach equilibrium (Dang, 1997). Other inputs used in the calculation are as follows:

- The percent zinc pyrithione in the treated article by total weight is 0.4% (based on same assumptions used for polyurethane sole liners);
- The total surface area of the impregnated material was assumed to be 500 cm^2 (i.e., the surface area of an impregnated article such as a storage container, based on the surface area of an impregnated toy) (Dang, 1997);
- The weight of the treated article is 50 grams, based on data that show a polyethylene highchair sample with a surface area of 12.7 cm^2 weighs 1.3072 g (i.e., 0.1 g/cm^2, or 0.1 g/cm2 * 500 cm^2 = 50 g) (Dang, 1997).

Using the above data and assumptions, the residue available at the surface at any one time is 0.000015 mg/cm^2.

The potential daily dose (Equation 7) was calculated using the surface residue obtained from Equation 6. The daily dose equation assumes that 50% of the available residue will be transferred from the treated article to the child's hands and then 50% of that residue will then be transferred to the child's mouth (i.e., saliva extraction factor). The surface area of the child's hand is assumed to be 20 cm^2, which represents the surface area of three fingers for a young child. Other inputs from Dang, 1997 which were used in the calculation are as follows:

- An exposure duration of 2 hours;
- A body weight of 10 kg for a 12 month old; and
- A mouthing frequency of 20 events per hour, which represents the 90^{th} percentile value for preschool aged children (ages 2-5 yrs) based on observations of video tapes.

This method is conservative because it does not account for washing of the treated article or depletion of the residue after each hand-to-mouth episode.

(3) Results

The oral potential daily dose through hand-to-mouth contact with treated polymeric articles was calculated to be 0.0003 mg/kg/day. Using 0.75 mg/kg/day for children as the NOAEL, the calculated MOE is 2500, which is greater than the target MOE of 300, and does not exceed the Agency's level of concern. These results are shown on Table 10.

Non-Dietary Incidental Ingestion of Preservative from Object-to-Mouth Contact

(1) Exposure Algorithims

Equation 8 was used to calculate the daily dose for object-to-mouth incidental ingestion exposure to children handling a treated article (e.g., a plastic storage container). An MOE was calculated using Equation 4.

Equation 8

$$PDD = \frac{Total\ SR \times F}{BW}$$

where:

PDD	=	Potential dermal dose (mg/kg/day)
Total SR	=	Total surface residue (mg) (0.0075 mg for a 500 cm^2 treated article)
F	=	Fraction Ingested (%) (50%, saliva extraction factor)
BW	=	Body weight of a 12 month old child (kg) (10 kg)

(2) Surrogate Exposure Data and Assumptions

The potential daily dose for object-to-mouth exposure is based on similar assumptions as the potential daily dose for hand-to-mouth exposures. The non-dietary ingestion of preservative from object-to-mouth contact uses "surrogate" exposure estimates from Dang (1997) and data from MRID 441086-02. The following assumptions were used in this assessment:

- A polyethylene highchair sample with a surface area of 12.7 cm^2 weighs 1.3072 grams (i.e., 0.1 gm/cm^2) (Dang, 1997).
- The total surface area of the impregnated material was assumed to be 500 cm^2 (i.e.,the surface area of an impregnated article such as a storage container, based on the surface area of an impregnated toy) (Dang, 1997).
- MRID 441086-02 estimates that out of 4,000 ppm of zinc pyrithione incorporated into polyethylene, only 1.5 ppm leached out under conditions of elevated temperatures and 10 days of extraction (0.00375% per day).
- 50% of the surface residue from the treated article is ingested (i.e., saliva extraction factor);
- The body weight is 10 kg (12 month old); and
- A child mouths 500 cm^2 of treated article surface per day.

Using these assumptions, a polyethylene sample with a surface area of 500 cm^2 weighs 50 grams (0.1 gm/cm^2 x 500 cm^2) and contains 0.4% ai of active ingredient. This assessment is conservative because it (1) does not account for washing of the treated article surface or depletion of the residue after each object-to-mouth episode, (2) assumes that 50% of the available residue is transferred and ingested (Dang, 1997), and (3) assumes that the amount accumulated under elevated temperatures is the amount available for contact for the each event per day.

(3) Results

The oral potential daily dose through object-to-mouth contact with treated polymeric articles was calculated to be 0.0004 mg/kg/day. Using 0.75 mg/kg/day as the NOAEL for children, the calculated MOE is 2000, which is greater than the target MOE of 300, and does not exceed the level of concern. This method is conservative because it does not account for washing of the treated article surface or depletion of the residue after each object-to-mouth episode and it assumes that 50% of the total available surface residues on the treated article is transferred and ingested. The MOE is presented in Table 10.

(5) Aggregate Postapplication Residential Risks

As shown in Table 10, the combined potential dose of exposure to treated polymeric articles (incidental ingestion) is 0.0007 mg/kg/day. Using 0.75 mg/kg/day as the NOAEL, the MOE for total exposure is 1,100, which is greater than the target MOE of 300. Therefore, risk resulting from contact with treated household articles does not exceed the level of concern. Dermal exposures were not aggregated with oral exposures, since the toxicological effects of concern are different. The total dermal MOEs are also greater than 300, and do not exceed the Agency's level of concern.

Table 10: Summary of Short-, and Intermediate- Term Residential Postapplication Exposure and Risks (c)

Scenario	Receptor	Use	PDR[a] (mg/kg/day)	Dermal MOE[b] Target MOE ≥300	Oral MOE[b] Target MOE ≥300
Dermal Contact to Polymeric Products Incorporated with Preservative (Shoe Liners)	Adult	Rubber/Plastic	4.06E-4	1,231	NA
	Toddlers		2.2E-2	4,500	NA
Non-Dietary Ingestion Object-to-Mouth (Polymeric Articles - Home Furnishings)	Infants	Rubber/Plastic	0.0004	NA	2,000
Non-Dietary Ingestion Hand-to-Mouth (Polymeric Articles - Home Furnishings)	Infants	Rubber/Plastic	0.0003	NA	2,500
Total Exposure and Risk	Infant	Rubber/Plastic	0.0007 (total oral)	NA	1,100
	Toddler		2.2E-2 (dermal)	4,500	NA
	Adult		4.06E-4(dermal)	1,231	NA

NA = Not applicable.

[a] PDR calculations for each scenario above are outlined in the text..

[b] MOE= NOAEL (mg/kg/day) / PDR (mg/kg/day). Developmental NOAEL is 0.5 mg/kg/day (for Adult Dermal MOE); Dermal NOAEL is 100 mg/kg/day (for Child Dermal MOE); Oral NOAEL general population and children is 0.75 mg/kg/day.

[c] Dermal risks are also for long-term exposures.

(6) Data Gaps, Uncertainties, and Limitations

Currently, zinc pyrithione chemical-specific handler or postapplication exposure studies that meet Agency guidelines have not been identified for use in assessing both occupational and residential exposures. Surrogate dermal and inhalation data primarily from the Pesticide Handlers Exposure Database (PHED) Version 1.1, the Chemical Manufacturers Association (CMA) database, and draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments were used to assess handler exposure. Surrogate data were not available for the following scenario:

- Mixing/loading/applying "powder" pesticide concentrates using metering

In order to characterize exposures for this scenario CMA unit exposure data for metering equipment for "liquids" was used as a surrogate for "powders". There is a possibility that this scenario may underestimate actual exposures.

In addition, note that CMA surrogate data have the following deficiencies:

- The inhalation concentrations were typically below the detection limits, so the unit exposures for the inhalation exposure route could not be accurately calculated.
- The quality of the CMA data were assessed using the same grading criteria as PHED and the grades were all at C,D,E lower than PHED standards (i.e., most of PHED is at grades A,B,C).
- Grade C,D,E data frequently may have QA/QC problems including lack of either/or field fortification, laboratory recoveries, and storage stability information.
- Grade C,D,E data has an insufficient amount of replicates.
- Grade C,D,E data may have higher variabilities (i.e., high CVs).

The following deficiencies of PHED and the residential SOPs should also be noted:

- Data includes all pesticides not just antimicrobial chemicals, so the results reported in PHED may be misleading.
- Pesticides are not usually volatile, so inhalation unit exposures may be underestimated for antimicrobial chemicals that are volatile.
- The job functions that commonly use pesticides may be different from those job functions using antimicrobial chemicals.
- The basic assumption underlying the database is that exposure to pesticide handlers is primarily a function of the physical parameters associated with handling and applying rather than the chemical properties of the individual active ingredients.

To assess postapplication dermal and incidental oral exposures, several sources of "surrogate" data were used to develop the residential scenarios, including an exposure assessment entitled "Health Assessment of the Use of Zinc Pyrithione Incorporated Into Polyurethane Sole Liners of Shoes" MRID

441086-01 (Olin Corporation, 1996) used in conjunction with the FDA Migration Study (MRID 441086-02) to predict the leach rate (U.S. EPA, 2003) in estimating dermal exposures to the preservative incorporated into polymeric materials. There are uncertainties associated with use of these data since the FDA leaching data generated on "polyethylene" might not best represent "polyurethane-treated" articles or leaching rates for other treated polymeric materials.

Data from the "Risk Analysis For Microban Additive "B" (Triclosan or Irgasan DP300) Treated Toys For Infants"(Dang, 1997) were used in combination with leach rate data from MRID 441086-02, and the Residential SOPs (1998, 2001) to develop child object-to-mouth and hand-to-mouth estimates from contact with treated polymeric articles (e.g., household furnishings/articles). There are uncertainties associated with this approach since these data and other assumptions used might not best represent actual leaching dynamics and residue loading, transfer, and ingestion.

3.0 REFERENCES

CMA. 1992. Chemical Manufacturers Association Antimicrobial Exposure Assessment Study. Popendorf, W, Selim, M., Kross, B. The University of Iowa. MRID 425875-01. December 8, 1992.

Dang. 1997. Risk Analysis for Microban Additive "B" (Triclosan or Irgasan DP300) Treated Toys for Infants. Memo From Winston Dang (Antimicrobial Division) to Frank Sanders and William Jordan (Antimicrobial Division), Dated February 24, 1997.

Garrod ANI, Guiver R, Rimmer DA. 2000. Potential Exposure of Amateurs (Consumers) through Painting Wood Preservative and Antifoulant Preparations. Ann. Occup. Hyg., Vol. 44, No. 6, pp.421-426.

PHED Surrogate Exposure Guide. 1997. Estimates of Worker Exposure from the Pesticide Handler Exposure Database Version 1.1. May 1997.

PHED Surrogate Exposure Guide. 1998. Estimates of Worker Exposure from the Pesticide Handler Exposure Database Version 1.1. August 1998.

Olin Corporation. 1996. "Health Assessment of the Use of Zinc Pyrithione Incorporated Into Polyurethane Sole Liners of Shoes." Laboratory Project ID ZPT-896. August 12, 1996.(MRID 441086-01).

U.S. EPA. 1995. Dermal Exposure Model Description and User's Manual. Draft Report. Prepared for Office of Pollution Prevention and Toxics. Exposure Evaluation Division. Contract No. 68-D3-0013.

U.S. EPA. 1997a. Standard Operating Procedures (SOPs) for Residential Exposure Assessments. Prepared for the Office of Pesticide Programs, Health Effects Division. Contract No. 68-W6-0030.

U.S. EPA. 1997b. Exposure Factors Handbook. Vol I-III. Office of Research and Development. Washington, D.C. EPA/600/P-95/002Fa.

U.S. EPA. 1998. Route-to-Route Extrapolations. Office of Pesticide Programs. Health Effects Division (HED). Memo From John E. Whalen (HED) to Margaret Stasikowski, Director. October 9, 1998.

U.S. EPA. 1999a. Zinc Pyrithione - Report of the Hazard Identification Assessment Review Committee. April 19, 1999.

U.S. EPA. 1999b. Evaluation of the Chemical Manufacturers Association Antimicrobial Exposure Assessment Study (Amended on December 8, 1992). Memorandum from Siroos Mostaghimi, Ph.D., Environmental Engineer to Julie Fairfax, PM #36. November 4, 1999.
U.S. EPA 2001. Residential Standard Operating Procedures, Science Advisory Council for Exposure, Policy 12. February 22, 2001.

U.S. EPA. 2003. Residue Chemistry Science Chapter for Zinc 2-pyridinethiol-1-oxide. Memorandum from A. Najm Shamim, Ph.D., Chemist to Julie Fairfax, PM #36.

U.S. EPA. 2004. Zinc Pyrithione: Revised Toxicology Endpoint Selection Report–Revised to address Registrant Error comments. April 1, 2004.