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Information on Borates Pertaining to the US GBC's LEED® EBOM Program

The US Green Building Council (US GBC) requires the use of "least-toxic" pesticides for IPM within LEED® compliant buildings, when pesticides are required to be used. Individual pesticides are classified as least-toxic (lowest concern) based on the Hazard Review Process developed by the City of San Francisco and rates the pesticides from Tier 1 (highest concern) to Tier III (least-toxic (lowest concern)). Products that are classified as Hazard Tier III do not require universal notification prior to application, unlike all other pesticide tiers.

The City of San Francisco's latest (2013) Hazard Review Process can be found at the following link: http://sfenvironment.org/sites/default/files/fliers/files/sfe_th_guide_to_reduced_risk_pesticide_listposted.pdf

As such, Rockwell has evaluated each of its pesticide products using this Hazard Review Process to support our clients servicing LEED® buildings. The Hazard Tier results can be found on Rockwell's website by going to each respective product page and clicking on the Hazard Tier link. This will bring you to the actual Hazard Process Review table for each pesticide wherein each hazard category entry is shown. Rockwell's borate products in particular have been evaluated and assigned a ranking of Tier III (least-toxic) based on the specific requirements of the Hazard Review Process.

To provide some historical context between LEED®, least-toxic pesticides, and San Francisco; one needs to be aware that at one time, The City of San Francisco Department of the Environment (SF) publicly published its own Reduced Risk Pesticide List. This list contained products that they had evaluated for internal use in their city IPM program. As outlined in their published criteria, they consider both the Hazard Tier and the Exposure Assessment when determining products they allowed for use in their program (Risk = Hazard x Exposure). Since SF was at the forefront of the "Green" revolution, many early LEED® professionals adopted this list as the authority on LEED® IPM with respect to pesticides. However, today SF no longer publishes its internal list, due to the problems it was causing for LEED® assessments. Many practitioners thought that a pesticide had to be on the SF Reduced Risk List in order to be used, which is not the case. This idea persisted even though SF stated that they did not maintain a national list, nor did they claim to have evaluated every product or even the best product available for their list. Further, their Reduced Risk list was developed for their own internal use within the City of San Francisco, not for LEED® use. So they discontinued publishing their annual list and instructed LEED® practitioners to evaluate and assign products hazard tier rankings based upon their published criteria (Hazard Review Process) in order to determine the best possible product for their needs.

More recently, an organization called Pesticide Research Institute (PRI) www.pesticideresearch.com was formed in their words as "an environmental consulting firm providing research, analysis, technical services and expert consulting on the chemistry and toxicology of pesticides". One of their services is publication of a list of pesticide hazard tiers, which they claim is based upon the published SF evaluation criteria. The list is available as an app via paid subscription. www.pesticideresearch.com/site/?page_id=467.

Interestingly, PRI has ranked borate products as Hazard Tier I in contrast to the Hazard Tier III ranking Rockwell determined using the published SF Hazard Review Process. To get a Tier 1 assignment, PRI claims that borates are reproductive/developmental toxins. The SF Hazard Review Process instructs product evaluators to consult two lists to determine if products are considered reproductive/developmental toxins. Specifically these lists are the California Prop 65 list http://oehha.ca.gov/prop65/prop65_list/Newlist.html and the EPA Toxics Release Inventory list https://www.epa.gov/sites/production/files/2015-12/documents/ry_15_tri_chemical_list.pdf. Upon reviewing both lists it becomes apparent that neither boric acid nor borax appears on them. If the borates had appeared on either of these two lists, then Rockwell would have classified them as Hazard Tier I, per the SF Hazard Review Process. However, they do not. Further, no other hazard categories evaluated in the Hazard Table for the borates triggers a classification other than Hazard Tier III.

When consulting with Dr. Susan Kegley, CEO of PRI as to why PRI classified borates as Hazard Tier I, she stated that it was due to reproductive/developmental toxicity and cited a report by the Danish EPA that classifies borates as reproductive toxicants http://mst.dk/service/publikationer/publikationsarkiv/2015/jul/survey-of-boric-acid-and-sodium-borates-borax/. This report is obviously not the same as the California and US EPA lists referred to in the SF IPM criteria for determination of reproductive/developmental toxicity.

Notwithstanding the discrepancy between what criteria PRI says it follows when evaluating pesticides and what it actually does, there is the question of what risk the use of borate pesticides may actually pose.

First, the referenced report from the Danish EPA is not specific to pesticide use. It is a report that looks at exposure from all sources:

"Borates are naturally present and widely distributed in the environment and boron is an important - if not essential- micronutrient to many species.

As indicated in chapter 3 boric acid and borax are used in many industries and for many purposes. The majority of the use (>50%) are used in the production of glass products (including glass fibre and glass wool) and ceramics where boric acid/borax is incorporated into and thus is a part of the glass/ceramic material. Other uses are in cosmetics, in biocides and in various chemical products such as soap and detergents, fertilizers, paint, varnishes, adhesives, electroplating, as catalysts, antifreeze products, lubricants and in cellulose (paper wool) insulation."

Second, the studies referenced for developmental toxicity are high-dose feeding studies wherein test animals were fed daily during pregnancy. Most of the reproductive/developmental toxicity studies referenced by the Danish EPA publication were conducted in the US and some are referenced in the US EPA Re-Registration Eligibility Decision for the borates (p 46-48), here: http://nepis.epa.gov/Exe/ZyNET.exe/20000AHB.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1991+Thru+1994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C91thru94%5CTxt%5C00000007%5C20000AHB.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL#

After thorough review, this data was not considered by EPA to indicate the need for restriction on the uses of borates as pesticides, and borates were actually exempted from the requirements of a tolerance on raw agricultural commodities due to residues above the naturally occurring level being insignificant.

Abstracts of several developmental toxicology studies contracted by the (US) National Toxicology Program are here (scroll down to boric acid on the alphabetic list and click on the chemical name to pull up each abstract): http://ntp.niehs.nih.gov/testing/types/dev/abstracts/index.html#B

An exhaustive list of abstracts of various published toxicology reports on boric acid is available from the National Toxicology Program: http://tools.niehs.nih.gov/cebs3/ntpviews/index.cfm?action=testarticle.toxicity&cas_number=10043-35-3

The listings related to epidemiology studies and studies on workers in borate production, pertaining to developmental toxicology are reprinted below:

- **EPIDEMIOLOGY STUDIES:** An ecological study assessed boron exposure from drinking-water and fertility among residents in two geographical regions in Turkey. Region I comprised 2368 residents, whereas Region II comprised 2319 residents. Boron levels in drinking-water were noticeably higher in Region I (range 2.05-29 mg/L) than in Region II (range 0.03-0.40 mg/L). Ever-married residents from each region who could provide reproductive histories for three generations of family members represented the study sample-- i.e. 159 probands (6.7% of population) in Region I and 154 (6.7%) in Region II. The percentages of married couples with one or more live births (>90%) were comparable for the two regions, regardless of generation assessed. The overall percentage of couples with unresolved infertility or those without children across three generations was comparable for the two regions (i.e. 6.0% and 4.6%, respectively). Secondary sex ratios (ratio of male to female live births) appeared to be different for the two regions. Region I had a ratio below 1 (0.89), suggesting an excess of female births; Region II had a ratio slightly above 1 (1.04), suggesting a slight excess of male births. Statistical significance was not formally evaluated in any of the above analyses. The results of this descriptive study suggest that fertility, as measured by the ability to produce a live birth, is not adversely affected for residents of this geographical area with high levels of boron in their drinking-water and soil. The observed reversal of the secondary sex ratio for Region I requires careful interpretation, as no attention was given to factors reported to alter sex ratios (e.g. advancing parental age, elective abortion rates, and multiple births).[WHO; Environmental Health Criteria Document 204: Boron p.100 (1998). Available from, as of May 12, 2005: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**
- **EPIDEMIOLOGY STUDIES:** There have been some epidemiology studies in Turkey comparing family birth rates in boron rich areas with those in lower-boron areas. Some village drinking waters are reported with boron levels as high as 29 ppm B. No evidence of reproductive toxicity was found in this population.[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1433] **PEER REVIEWED**
- **HUMAN EXPOSURE STUDIES:** ... Collected boron exposure/dose measures in workplace inhalable dust, dietary food/fluids, blood, semen, and urine from boron workers and two comparison worker groups (n=192) over three months and determined correlations between boron and semen parameters (total sperm count, sperm concentration, motility, morphology, DNA breakage, apoptosis and aneuploidy). Blood boron averaged 499.2 ppb for boron workers, 96.1 and 47.9 ppb for workers from high and low environmental boron areas (p<0.0001). Boron concentrated in seminal fluid. No significant correlations were found between blood or urine boron and adverse semen parameters. Exposures did not reach those causing adverse effects published in animal toxicology work but exceeded those previously published for boron occupational groups.[Robbins WA et al; Reprod Toxicol. 29 (2): 184-90 (2010)] **PEER REVIEWED** PubMed Abstract
- **HUMAN EXPOSURE STUDIES:** ... The present study was conducted to investigate the reproductive effects of boron exposure in workers employed in boric acid production plant in Bandirma, Turkey. In order to characterize the external and internal boron exposures, boron was determined in biological samples (blood, urine, semen), in workplace air, in food, and in water sources. Unfavorable effects of boron exposure on the reproductive toxicity indicators (concentration, motility, morphology of the sperm cells and blood levels of follicle-stimulating hormone (FSH), luteinizing hormone (LH), and total testosterone) were not observed. The mean calculated daily boron exposure (DBE) of the highly exposed group was 14.45 +/- 6.57 (3.32-35.62) mg/day. These human exposures represent worst-case exposure conditions to boric acid/borates in Turkey. These exposure levels are considerably lower than exposures, which have previously led to reproductive effects in experimental animals. ...[Duydu Y et al; Arch Toxicol. 85 (6): 589-600 (2011)] **PEER REVIEWED** PubMed Abstract

- **HUMAN EXPOSURE STUDIES:** Limited data were located regarding reproductive effects in humans after inhalation exposure to boron. One study reported ... occupational exposure (10 years or greater) to boron aerosols (22-80 mg/cu m) in males engaged in the production of boric acids. The study group was small, consisting of 28 men. Low sperm counts, reduced sperm motility and elevated fructose content of seminal fluids were observed.[DHHS/ATSDR; Toxicological Profile for Boron (PB/93/110674/AS) (July 1992). Available from, as of April 25, 2005: http://www.atsdr.cdc.gov/toxpro2.html] **PEER REVIEWED**

Epidemiological studies conducted in Turkey (the world's leading miner of borates) comparing regions with substantially different levels of borate in drinking water did not show any differences of significance in reproductive success among resident populations.

The worst case scenario for boron exposure is in those occupationally involved in borate mining/production. Even these worst case scenario levels of exposure were considerably lower than the levels that are required to show reproductive effects in animal studies. Two recent studies (2010 and 2011) showed no reproductive toxicity effect in boron workers. One older study (1992) with a low number of participants (28) who were occupationally exposed to high levels for 10 years or greater did show some negative effects on sperm count and motility only.

The fact that even working in a borate factory environment does not cause one's exposure to reach the levels that were required to show reproductive/developmental effects in animal feeding studies is perhaps the most compelling argument that simply occupying a building treated with a borate pesticide product would have no risk of potentially harmful levels of exposure. Further, any exposure from pesticide use would be difficult to separate from background levels of these naturally occurring compounds that are widely used for many other purposes, as was stated in both the Danish report and the US EPA RED. Outside of intentional ingestion of baits or powder, or intentional inhalation of powder, there is no risk of reproductive/developmental effects from use of EPA-registered borate pesticides in buildings per the label. Borates are inorganic compounds, so they don't have a vapor pressure and do not volatilize into the air the way a volatile organic pesticide can. Neither the US EPA nor the State of California classifies these products as reproductive/developmental toxicants. Further, the head of the San Francisco IPM Program confirmed that they use borate pesticides in their program because they understand the exposure is very low. Boric acid and borax are natural compounds with a very long history of use for many purposes. They are valuable and environmentally responsible tools for Integrated Pest Management.

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