Wood treatment guideline

DOT dip diffusion

CRAterre
ENSAG

Introduction

Many different methods using natural wood preservatives or synthetic wood treatments are available: from traditional techniques and recipe like wood smoking to more industrial process like pressure impregnation.

The type of preservative considered in this guideline is a borate compound called **Disodium Octaborate Tetrahydrate (DOT)**, a safe and effective wood preservative, which seems to be one of the best acceptable option so far according to the current state of knowledge. The methods describe are the dip diffusion and surface application that can be carried out preventively or curatively.

Dip diffusion with DOT is a wood treatment method largely used by log home manufacturers. The wood to be treated is placed for some minutes in a tank/trench full of DOT solution and later removed and wrapped for several days so that the DOT can diffuse into the log. Multiple dip treatments are not unusual with further wrapping to insure a complete penetration of the log.

This guideline is the result of several exchanges and experimentations realized by local and international organizations who have been recently using DOT wood preservative during reconstruction projects in Haiti and Nepal.

Table of contents

Topics covered by this guideline are the following:

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Disclaimer

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Before implementing the methods described in this guideline, make sure to carefully understand the efficiency, easiness, cost and safety of the process. The authors and all the organizations mentioned shall not be responsible for any injuries, losses, and other damages that may result from the misuse of the information of this guideline or its wrong interpretation.

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1 GENERAL INFORMATION

Why wood treatment is needed?

Wood is a natural organic material and as such, can be degraded by biological organisms: bacteria, fungi (rot) and insects (woodworms and termites). Wood is also vulnerable to direct sun light and moisture, which affect its durability and increase the rotting process.

There are many different species of wood, and depending of its type and hardness, each one has its own characteristic and ability to resist the conditions that give rise to decay. For preventing insects, rotting and moisture degradation and ensuring its durability over time, several good practices can be carried out:

This wood piece that was preventively painted for protecting it was completely eaten by termites within the course of 8 months.
©CRAterre, Sindhulpalchok, Nepal

- Proper tree selection (specie).
- Cutting of trees at the proper season (lunar phase).
- Thorough drying process and seasoning.
- Proper stocking procedures.
- Appropriate architectural details (awnings, overlapping roof, post base, etc.).
- Water/insect/rotting resistant treatment.

What is DOT?

DOT stands for **Disodium Octaborate Tetrahydrate** ($Na_2B_8O_{13}\cdot 4H_2O$). It is a natural borate mineral salt mined from the land. The active component is boron, which is one of seven micronutrients essential to all plant growth. Boron-based compounds for wood treatment were developed in New Zealand and Australia in the 1930s and became commercialized in 1949. Over nearly 70 years borate mineral has been used worldwide proving its efficiency as wood treatment.

DOT is known to be an effective, eco-friendly and low-cost remedy for killing rot organisms and wood-destroying insects in infested wood and preventing its recurrence. It can be easily found in market place in a clear, liquid concentrate (e.g. Bora-Care®[1]) or in a colorless crystals or white powder that is soluble in water (e.g. Tim-Bor®).

A DOT solution can be also homemade by mixing water with **Boric Acid** (H_3BO_3) and **Borax** ($Na_2B_4O_7\cdot 10H_2O$) (see section 4: DOT Homemade recipe)

Dip diffusion is a wood treatment method largely used by log home manufacturers. The wood to be treated is placed for some minutes in a tank/trench full of DOT solution and later removed and wrapped for several days

[1] The formulation of Bora-Care® also contains glycol penetrants to help the active ingredient diffuse into the wood.

so that the DOT can diffuse into the log. Multiple dip treatments are not unusual with further wrapping to insure a complete penetration of the log.

DOT Benefits

- Kills xylophagous insects (woodworms and termites).
- Bactericide and fungicide.
- Fire retardant in some wood applications depending on borate loading and type used.
- Low toxicity compared to other wood preservatives.
- Simple to use, which allows the setting of small scale treatment units.
- Affordable when homemade.

DOT toxicity compares to other wood preservatives

DOT preservative is known to be a more environmentally friendly than other wood preservatives currently used. It does not contain copper, arsenic or other heavy metals[2]. However, certain caution should be taken in the use of boron product (see section 10: Security and precaution).

How does DOT work to get rid of wood destroying insects and prevent rotting decay?

When ingested by xylophagous insect DOT acts as a stomach poison affecting the insects' metabolism. It appears to disrupt the nervous system and digestive process of termites.

Because of its bactericide/fungicide characteristic, DOT also control rotting decay by disrupting cellular production of enzymes that allows fungi to extract nutrients from the wood.

DOT's functionality in wood

DOT is a water-soluble solution that can easily penetrate dry and wet wood. It takes advantage of the moisture content in the wood to penetrate deeper. For fresh cut timber, where the moisture content can be 35% or higher by weight, the DOT solution penetrates timber logs more completely and faster.

The wood species is also important since DOT will penetrate further and faster in soft wood species (i.e. pine, spruce, fir, etc.) versus hard wood species (i.e. oak, elm, etc.).

The depth of penetration will vary depending of:

- DOT concentration.
- Number of treatments applied.
- Duration of soaking and diffusion process.
- Surrounding temperature.
- Age, moisture and species of wood.

[2] For more information regarding wood treatment toxicity you can refer to the guideline *Timber as a construction material in humanitarian operations*, which is available for download http://www.humanitariantimber.org/index.html

2 SOAKING CONTAINER

Different types of soaking container can be realized or used: concrete container; plastic container; metal tank (using for example a series of metal drums cut in half and welded together); wooden tank; trench on the ground. The two last one can be built as follows:

Wooden tank

- The length of the tank must be chosen according to the length of wood to be treated. For woods of 16', built a 17' long tank (inside).
- The width and depth of the tank must allow easy manipulation (a width of 3’ and a depth of 2’ is recommended).
- Use screws instead of nails so that you can easily assemble/disassemble the tank. Be careful that screws or nails are not coming out, that could perforate the tarpaulin.
- Side pressures when tank is full are important, provide horizontal reinforcement accordingly.
- Prepare a lid (e.g. CGI roofing sheets) to cover and protect the tank and the solution.

Wooden tank.
©CRAterre, Haiti

Advantage	Disadvantage
More comfortable to use (at man's height). More resistant. Allows inside installation. Allows several dismounting and assembling.	Requires greater initial investment**.**

Trench on the ground

- Choose a firm ground to dig a clean, stable pit (to avoid the risk of trench edges collapsing).
- Dig a pit of the tank dimensions; check that there are no sharp elements in the pit (stones, roots) that could perforate the tarpaulin.
- Place 1” thick of soft materials (saw dust, straw) on the bottom of the tank to avoid any perforation of the tarpaulin.
- Clean the surrounding surface of the trench to ensure that no earth or dust or any other thing can fall into the container.
- Prepare a lid (e.g. CGI roofing sheets) to cover and protect the tank and the solution.

Trench being dig.
©CRAterre, Sindhulpalchok, Nepal

Advantage	Disadvantage
Easy to make. Cheap.	Outdoor use only, but can be covered by a structure. Less comfortable to use. Need to be protected from children falling (using CGI roofing sheets for instance).

Waterproofing of the soaking container

- Waterproofing of the tank/trench can be achieved by using a tarpaulin. Choose a tarpaulin that is resistant and completely waterproof, do not use woven tarpaulins.
- Tarpaulins size must allow to be folded several times (at least twice) to improve its resistance and waterproofness.
- Make sure there is no leakage to avoid loss of solution. It is recommended to have empty buckets and drums available in case a leak occurs to be able to quickly transfer the product.
- Install the tarpaulin tightly against the walls of the tank/trench, leaving sufficient margin to prevent the tarpaulin from being perforated during filling. Fix the tarpaulin on the sides so that it is stable and secure.
- Test the waterproofing of the tank/trench with water before putting the treatment solution.
- Clean the surrounding surface and ensure that no dust can go inside.

Waterproofing of a wooden tank using a tarpaulin.
©CRAterre, Haiti

Note: Once built, if only small pieces of wood need to be treated, the size of the container can be easily reduced using extra wood planks to divide the volume.

3 WOOD PREPARATION

Choice of wood to be treated

As the treatment process requires some careful handling and time, ensure to prepare in advance all the wooden elements that need to be treated.

If treating all wooden elements appears to be too expensive or difficult to realized, it is important to prioritize wooden elements that cannot be disassembled or those which decay control are difficult: such as structural elements (beam, carpentry elements) and inclusions.

Cutting and polishing

- Before the treatment, all wood preparations that can be anticipated must be achieved, including polishing the wood, some cut-outs (for ex. cutting standard elements such as posts, beam, bands, purlins, etc.). Wood surfaces must be dry and cleaned of oily and greasy contaminants. Previous coatings must be removed.
- Once the wood has been treated, it is more difficult to plane (wood treated with DOT wear out tools quicker). Planing wood after treatment should be avoided, as the outer skin of wood are the better treated part and act as a protective barrier.

Wood moisturizing

- Since the principle of DOT treatment is osmosis diffusion, it is possible or even preferable to treat fresh wood (the fresh, green wood is already moist so the solution will diffuse easily inside the wood). It is therefore not necessary to dry the wood before treatment.
- For already dry wood, it should be wetted profusely before immersing in the tank to improve the penetration of the solution into the wood during soaking. It is recommended to water it on a tarpaulin or to immerse it in a tank of water in advance for at least 1h or 2h.

4 DOT HOMEMADE RECIPE

When commercial wood preservatives (Tim-Bor® or Bora-Care®) are not available or too expensive a combination of Boric Acid and Borax can be prepared.

10% DOT solution

For construction purpose, a 10% DOT solution is adequate to provide sufficient protection. For making the equivalent of a 10% DOT solution, a 2:3 ratio mix can be used[3]. It can be made for example by slowly adding 50kg of Boric Acid and 75kg of Borax to 700 liters of water while stirring the solution (See Annex Conversation table for making homemade DOT solution)

15% DOT solution

In case you want to use a DOT solution for surface application a 15% DOT solution can be used. It can be made by slowly adding 79kg of Boric Acid and 119kg of Borax to 700 liters of water (See Annex Conversation table for making homemade DOT solution).

Coverage and cost

Approximately 1 US Gallon (3,79 L) of a 10% solution will be needed to treat 200 square feet (18,6m²) of wood surface area depending on the absorbency of the timber.

In Nepal, Boric Acid and Borax can be purchased from agricultural fertilizer dealers at a rate of 2 to 4 USD/kg (2017 rate). For large order, make sure to place it in advance to avoid delays and product shortage

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[3] This ratio is used and promoted by the Environmental Bamboo Foundation in Indonesia for treating bamboo for construction purpose. See http://www.bamboocentral.org

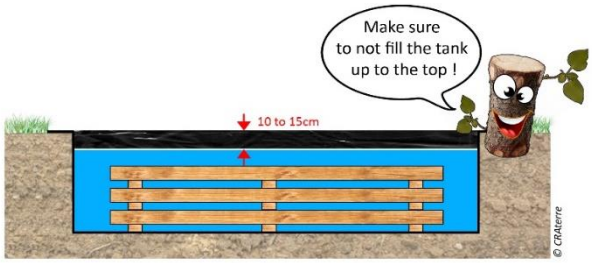
5 DILUTION PROCESS

For ready made products, check the product's technical indications.

For homemade recipe, to facilitate the mixing of the Boric Acid and Borax with water and avoid the risk of breaking the tarpaulin during mixing, it can be proceeded as follows:

Step 1

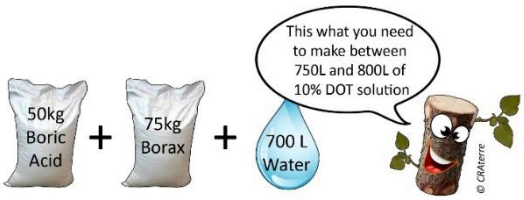
Calculate the quantity of solution to be prepared to fit with the volume of the tank/trench and the volume of wood that will be placed inside the tank/trench. Make sure that the level of solution is 10 to 15cm below the maximum level of the tank/trench.



Quantity of solution = Volume of the tank/trench - Volume of wood that will be treated inside the tank/trench.

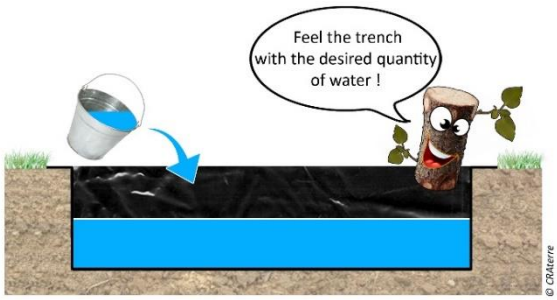
Step 2

Prepare the quantity of Boric Acid and Borax needed (see section 4: DOT Homemade recipe) according to the volume of solution desired. Before mixing with water, Boric Acid and Borax can be mixed together (dry mix). Ensure to follow adequate safety measures when handling the products (see section 10: Security and precaution).



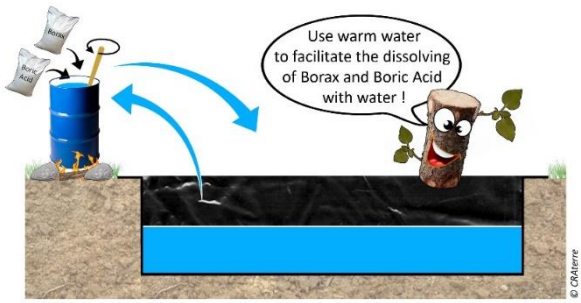
Step 3

Pour the total volume of required water into the tank.



Step 4

Dilute the Boric Acid and Borax with water. Gradually dilute some quantity of Boric Acid and Borax with water collected from the tank/trench (so that the proportion of the dilution remains the same). Mix until crystals are completely dissolved. Pour this mixture into the tank/trench. Repeat this procedure until you have completely mix the quantity of Boric Acid and Borax salts needed. The warmer the water is, the easier it will be to dissolve them. Water between 20 and 30°C is adequate. It may thus be necessary to heat up the water before mixing.



Step 5

Stir the solution. Once the whole amount of Boric Acid and Borax are mixed, keep stirring the solution inside the tank/trench until it is completely homogeneous before starting to soak the wood (buckets can be used to do so, to prevent any punctures in the tarpaulin).

Step 6[4]

Check the DOT concentration level. The DOT concertation can be checked using a hydrometer (an instrument used to measure the specific gravity or relative density of liquids). Make sure to operate the hydrometer during average temperature (between 20-25°C). Check the DOT concertation after the dilution process in order to get a base value to refer to[5]. To test the solution slowly add the DOT solution into a test container (bucket, etc.), so that you avoid air bubbles in the solution. Make sure their no bubbles around the hydrometer before reading the scale.

[4] This step is optional as it depends on the availability of hydrometer.

[5] According to the guideline *Vertical Soak diffusion for bamboo preservation VS3* (see http://www.bamboocentral.org), a 10% DOT solution should give a reading between 1.050 and 1.053 (water is 1.000).

6 DIP DIFFUSION

Soaking

- Place the wood into the tank/trench, paying attention not to damage the tarpaulin.
- Interpose small pieces of wood between the logs so that their surface is fully in contact with the DOT solution.
- Once all the woods have been placed, load them with clean stones so that they are completely immersed.
- To simplify the process, it is recommended to place the wood in homogeneous lots: same section.
- **Wait some time according to your treatment protocol (see section below).**

Wood soaking.
©CRAterre/ASF-Nepal, Gorkha, Nepal

Draining

To drain the timber, place cross-beams on the tank/trench to allow the wood to be placed on top of them for about 30 seconds to 1 minute before being taken to storage. This allows to collect a little bit of DOT solution that drips into the tank/trench.

Note: In case of several hours/days break between two treatment sessions, draw a line with a permanent marker inside the tank/trench corresponding to the level of your solution to check the degree of evaporation. If after few hours/days the level has decreased, add water until the solution level reaches the level drawn before. In this way, the concentration is conserved (the water evaporates but not the boron minerals).

Wood draining.
©CRAterre/ASF-Nepal, Gorkha, Nepal

Diffusion

Directly after soaking and draining, the wood should be first properly stored:

- On a flat surface, raised from the ground by woode n crossbeam or stones.
- Keep some spaces in between every piece of wood and in every layer. It can be done with separators, made of wood, bamboo or rope. Separators should be on the top of each other's, aligned above the crossbeams at the bottom of the pile.

Wrapping and stocking of treated wood.
©CRAterre/ASF-Nepal, Gorkha, Nepal

Diffusion is the phase during which the DOT solution penetrates deep into the wood (by osmosis). If the drying is too fast, the diffusion will be not sufficient and only the wood surface will be treated. It is therefore necessary to carefully wrap the wood in a tight cover as soon as it leaves the soaking tank.

The wood must stay wrapped for several hours or days away from rain, sun and wind to ensure the diffusion of the solution into the wood core. It can also be stored until it is transported to the building site.

Treatment testing protocol

Soaking and diffusion time vary depending on the wood type. The greener the wood is, the shorter time for soaking and diffusion is necessary. For more dense wood, the soaking and diffusion time must be adjusted.

It is recommended to test several combinations of soaking and diffusion time to find the best protocol that is adapted to your wood. To facilitate this testing process, you can use wood samples (1' long) soak in a bucket filled with DOT solution. The quality control test with Dye and Visualization Reagent makes it possible to check the results by modifying the soaking / diffusion times (see section 7: Quality control).

The table below provides some indications for adjusting the soaking / diffusion time according to the type of wood.

Type of wood	(moisture content in % of wood's weight)	Initial wood moisturizing	Soaking time	Diffusion time
Fresh cut wood (soft wood)	30 to 40%	unnecessary	30mn to 1h	2 to 4 days
Fresh cut wood (hard wood)	30 to 40%	unnecessary	30mn to 1h	3 to 10 days
Dried wood (soft wood)	10 to 15%	1h to 2h in water	1h to 2h	2 to 4 days
Dried wood (hard wood)	10 to 15%	1h to 2h in water	1h to 2h	3 to 10 days

To save your results and data, you can use the **Treatment Testing Table in annex**.

7 QUALITY CONTROL

To establish quality control, it is necessary to determinate the penetration and retention of the solution in the wood.

Dye preparation

- Mix **10g of Turmeric/Curcuma** with **100ml of Alcohol** (the alcohol must have a concentration greater than 90%).
- Store this solution in a plastic container.

Visualization Reagent preparation

- Dissolve **6g of Salicylic Acid** ($C_7H_6O_3$) in **100ml of Alcohol** (the alcohol must have a concentration greater than 90%).
- Mix **20ml of Hydrochloric Acid** (HCl) **at a concentration of 34%** or **22ml of Hydrochloric Acid** (HCl) **at a concentration of 31,45%** with the Salicylic Acid/Alcohol solution.
- Store this solution in a plastic sprayer bottle.

Quality control process

- Select one or two timbers from your treated wood stock. Cut a sample of 30cm long.
- Paint the Dye solution with a brush on the cross-sections that was just cut.
- Once the Dye solution has dried, apply the Visualization Reagent with a spray on the cross-sections.
- Let dry for some minutes before interpreting the results.

Dye application on a wood section sample.
©CRAterre/ASF-Nepal, Magapauwa, Dolakha, Nepal

Sparying of the Visualization Reagent.
©CRAterre/ASF-Nepal, Magapauwa, Dolakha, Nepal

Results interpretation

The effectiveness of the treatment is realized by observing the coloration of the cross-section cuts.

- Wood parts that became red indicate the level of DOT retention inside the wood.
- Penetration level is checked by measuring the displacement of the coloration from the edge towards the center. This value shall be, as far as possible, equal to half of the thickness of the treated wood.
- The color of the Visualization Reagent depends on the DOT concentration. The color samples below show the various retentions of boron in kg/m^3.

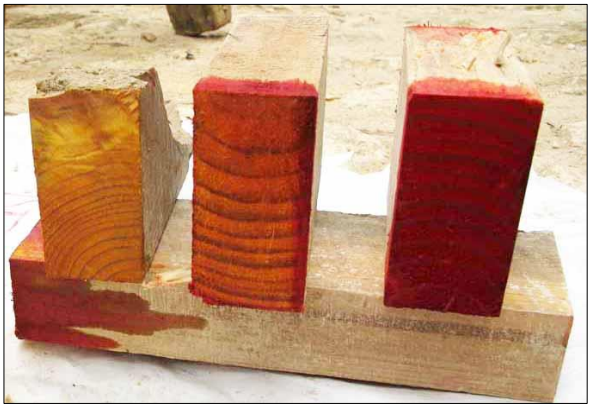
Natural color

0.186 kg/m^3

0.756 kg/m^3

0,874kg/m^3

Wood section that shows a homogeneous concentration of DOT solution.
©CRAterre/ASF-Nepal, Magapauwa, Dolakha, Nepal



From left to right: no treatment; middle DOT concentration; high DOT concentration).
©CRAterre, Haiti

8 SURFACE APPLICATION

For houses and other structures that have previously been built, the DOT solution can be also used as a curative treatment in an infected house for killing or repelling wood-destroying and cellulose-consuming organisms and insects. It can also be used as a preventive treatment to prevent future infection and deterioration (for example during repairs or maintenance).

This approach uses surface application: painting and spraying methods. This kind of application can provide some protection but the level of wood penetration is minimal compared to dip diffusion treatment.

Wood preparation

To improve the penetration of the DOT solution:

- If wood is painted, it must be sanded.
- Wood must be cleaned with soap and water to remove dust and grease.
- Whenever possible, wood may be wetted with water prior the application of the DOT solution in order to facilitate its penetration.

Application

- The DOT solution can be applied with a brush or sprayed on all wood visible surfaces (wood posts, beams, decks, fences, steps, etc.) making sure that safety precautions are followed (see section 10: Security and precaution).
- If using a 10% solution, two coats must be applied. The second coat can be applied after 24 hours drying time.
- If using a 15% solution, a single coat should be enough.
- Syringe injection can be also performed into wood holes.
- After application, treated wood must be protected from sun, wind and rain to allow a better penetration of the DOT solution inside the wood.
- Whenever possible, it is also recommended to cover and seal with tarpaulins the treated wood for at least 48 hours to increase the diffusion of the DOT solution.

Quality control

To verify the quality of treatment (see section 7: Quality control):

- Apply with a spray the Dye solution on the surface of the wood.
- When dry, apply the Visualization Reagent.
- Check the coloration of the wood surface.

9 DURABILITY & PROTECTION

Wood treatment with a DOT solution provides a termite and rot resistant envelope treatment that can last for **30 years or more**. While water will evaporate from the borate solution, borates salts are stable within the wood assuming that there is no external moisture source to leach the borate mineral.

Because DOT is water-soluble, it means that it **is not a permanent solution for timber that is continually exposed to water**. DOT can be leach from the wood if there is a moisture source on the wood. However, additional precaution and protection measures can be applied to increase the treatment durability:

Seasoning

After the diffusion, if the wood treated was fresh cut wood, adequate drying and seasoning should be realized.

Protection during storage and transport

After the diffusion, during the transport and storage on the construction site, it must be ensured that the treated wood is protected from the rain, so the DOT solution won't be washed away.

Protection with painting and varnishing

To protect exposed treated wood from excess rain and moisture it is also possible to apply a paint (primer + microporous paint) or varnish or stain. Inside wood or unexposed wood doesn't need to be protected. Make sure to follow the below recommendation:

- Apply when the wood is completely dry.
- Before application, gently wash off the surplus of DOT on the surface, otherwise surface residue may inhibit paint/varnish/stain adhesion or discolor the paint.

Note: Be careful with the use of varnish for wood protection; it might cause damage for wooden elements that are exposed to humidity (the varnish can prevent the wood from drying). If using oil-based paint, avoid using too much solvent (paint thinner) as it reduces the waterproofing effectiveness.

Application of protective coats:
first coat with a primer (in white),
second coat with an oil based paint (in brown).
©Vincent Pena, Rapcha, Solokhumbo district, Nepal

DOT fixing with Silicates

To fix the DOT inside the wood and prevent its leaching, silicates (sodium or potassium silicate) can be added to the mix during the soaking phase. The function of the silicate is to act as fixing agent that allows the DOT to become fixed inside the wood and enables it to resist from being wash away.

Additional DOT application

Additional DOT applications could be also considered to increase the durability of the initial treatment, but this additional coat might be more expensive and difficult to realize than applying a protective coat with paint/varnish/stain.

10 SECURITY & PRECAUTION

Boric Acid (H_3BO_3) and **Borax** ($Na_2B_4O_7 \cdot 10H_2O$) are generally considered to be safe to use. The main effect of exposure is irritation due to the mildly corrosive nature of borate dusts and solutions.

Hydrochloric Acid (HCl) and **Salicylic Acid** ($C_7H_6O_3$) are highly corrosive and toxic products. These chemicals should be therefore handle with care.

For all products, following measures should be applied:

- Handle in a well-ventilated place (preferably outside).
- Use protective goggles, waterproof gloves and safety mask.
- Store in a safe place away from foodstuffs and out of reach of children and pets (locked room or cabinet).
- Store products in a cool and dry place in leakproof containers (not metal containers) with the word DANGEROUS with the name of each product and solution.
- Do not pour left over product down on the soil and avoid spillage into soil and water.
- Unwanted Boric Acid and Borax solution should be dried up for being re-used.
- Make sure operators are aware of hazards and prevention measures.

The preceding information is given as a general guide only, please refer to more comprehensive detail on each of the products looking at **the Safety Cards in annex**.

11 REFERENCES & ANNEXES

Database and web resources

- About borate: http://www.americanborate.com/all-about-borates
- International Chemical Safety Cards database: http://www.ilo.org/dyn/icsc/showcard.home

Articles and guidelines

- Timber as a construction material in humanitarian operations. IFRC, UN/OCHA, CARE International. 2009, 90p. http://www.humanitariantimber.org/index.html
- Vertical Soak diffusion for bamboo preservation VS3, The Environmental Bamboo Foundation (EBF), Third Edition: October 2005, http://www.bamboocentral.org
- Preservación de melina mediante el método inmersión - difusión con sales de boro, Róger Moya, Laura Leandro, Francisco Monge in Kurú: Revista Forestal (Costa Rica) 1(2), 2004, http://revistas.tec.ac.cr/index.php/kuru/article/view/579
- Preserving Bamboo with Borates, ECHO Asia Notes, Thomas Singer, Issue 4, January 2010, https://www.sheltercluster.org/sites/default/files/docs/preserving_bamboo_with_borates.pdf

Annexes

- **Conversion table** for homemade DOT solution
- **Treatment testing table**
- **Borax** safety card (ICSC database).
- **Boric Acid** safety card (ICSC database).
- **Hydrochloric Acid** safety card (ICSC database).
- **Salicylic Acid** safety card (ICSC database).

ANNEX **Conversion table** for homemade DOT solution

Conversion table for making a **10% homemade DOT solution.**

In Liters (L)

Water (H_2O)	250 L	500 L	700 L	1000 L	1250 L	1500 L
Boric Acid (H_3BO_3)	18 kg	36 kg	50 kg	71 kg	89 kg	107 kg
Borax ($Na_2B_4O_7{\cdot}10H_2O$)	27 kg	54 kg	75 kg	107 kg	134 kg	161 kg

In US Gallon (gal)

Water (H_2O)	50 gal	100 gal	150 gal	200 gal	250 gal	300 gal
Boric Acid (H_3BO_3)	14 kg	27 kg	41 kg	54 kg	68 kg	81 kg
Borax ($Na_2B_4O_7{\cdot}10H_2O$)	20 kg	41 kg	61 kg	81 kg	101 kg	122 kg

Conversion table for making a **15% homemade DOT solution.**

In Liters (L)

Water (H_2O)	250 L	500 L	700 L	1000 L	1250 L	1500 L
Boric Acid (H_3BO_3)	28 kg	57 kg	79 kg	114 kg	142 kg	170 kg
Borax ($Na_2B_4O_7{\cdot}10H_2O$)	43 kg	85 kg	119 kg	170 kg	213 kg	255 kg

In US Gallon (gal)

Water (H_2O)	50 gal	100 gal	150 gal	200 gal	250 gal	300 gal
Boric Acid (H_3BO_3)	22 kg	43 kg	64 kg	86 kg	107 kg	129 kg
Borax ($Na_2B_4O_7{\cdot}10H_2O$)	32 kg	64 kg	97 kg	129 kg	161 kg	193 kg

Note: Due to the volume and dissolvability of Boric Acid and Borax, keep in mind that the total volume of solution obtained will be more than the initial volume of water but less than the sum of all components volumes. For example, for 50kg of Boric Acid + 75kg of Borax + 700 liters of water, the total volume of 10%DOT solution is estimated to be between 750L to 800L.

ANNEX Treatment testing table

It is recommended to test several combinations of soaking and diffusion time to find the best protocol that is adapted to your wood. The below table can help you to save your results and data.

Wood local name:	
Wood common name:	
Wood scientific name:	

		Soaking time					
		30mn	**45mn**	**1h00**	**1h30**	**2h00**	**Other:**
Diffusion time	**2 days**	Sample N°: Date*:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	3 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	4 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	5 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	6 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	7 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	8 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	9 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	10 days	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	Other 1	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	Other 2	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:
	Other 3	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:	Sample N°: Date:

* The date refers to the starting date of the diffusion process

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BORIC ACID

ICSC: 0991

Peer-Review Status: 11.04.2014 Validated

Boracic acid
Orthoboric acid

CAS #: 10043-35-3 RTECS #: ED4550000
EC #: 005-007-00-2
EINECS #: 233-139-2

Formula: BH_3O_3 / $B(OH)_3$ / H_3BO_3
Molecular mass: 61.8

TYPES OF HAZARD / EXPOSURE	ACUTE HAZARDS / SYMPTOMS	PREVENTION	FIRST AID / FIRE-FIGHTING
FIRE	Not combustible. Gives off irritating or toxic fumes (or gases) in a fire.		In case of fire in the surroundings, use appropriate extinguishing media.
EXPLOSION			
EXPOSURE		**PREVENT DISPERSION OF DUST! STRICT HYGIENE!**	
Inhalation	Cough. Sore throat.	Use local exhaust or breathing protection.	Fresh air, rest.
Skin	No acute symptoms expected.	Protective gloves. Protective clothing.	Rinse and then wash skin with water and soap.
Eyes	Redness. Pain.	Wear safety spectacles or eye protection in combination with breathing protection.	Rinse with plenty of water (remove contact lenses if easily possible).
Ingestion	Nausea. Vomiting. Diarrhoea. Abdominal pain. Skin rash. Headache. Drowsiness. Convulsions.	Do not eat, drink, or smoke during work.	Rinse mouth. Do NOT induce vomiting. Refer immediately for medical attention.

SPILLAGE DISPOSAL

Personal protection: particulate filter respirator adapted to the airborne concentration of the substance. Sweep spilled substance into covered containers. If appropriate, moisten first to prevent dusting. Wash away remainder with plenty of water.

PACKAGING & LABELLING

EC Classification
R: 60-61; S: 53-45; Symbol: T
UN Classification

GHS Classification
Signal: Danger
May damage fertility or the unborn child

EMERGENCY RESPONSE

SAFE STORAGE

	Separated from strong bases.

IMPORTANT DATA

Physical State; Appearance
ODOURLESS COLOURLESS CRYSTALS OR WHITE POWDER.

Physical dangers

Chemical dangers
Decomposes above 100°C . This produces water and irritant boric anhydride. The solution in water is a weak acid. Attacks metals. This produces hydrogen. This generates fire and explosion hazard.

Occupational exposure limits
TLV (inhalable fraction): 2 mg/m³ as TWA; 6 mg/m³ as STEL; A4 (not classifiable as a human carcinogen); (ACGIH 2014).
MAK (inhalable fraction): 10 mg/m³; Peak limitation category: I(1); Pregnancy risk group: B; (DFG 2013).

Routes of exposure
The substance can be absorbed into the body by inhalation of dust and by ingestion.

Inhalation risk
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly , especially if powdered.

Effects of short-term exposure
The substance is irritating to the respiratory tract. May cause mechanical irritation to the eyes. The substance may cause effects on the central nervous system and kidneys. This may result in impaired functions.

Effects of long-term or repeated exposure
Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the testes. Animal tests show that this substance possibly causes toxicity to human reproduction or development.

PHYSICAL PROPERTIES

Decomposes at 171°C
Relative density (water = 1): 1.5
Solubility in water, g/100ml at 20°C: 5.6
Vapour pressure at 20°C: negligible
Octanol/water partition coefficient as log Pow: -1.09

ENVIRONMENTAL DATA

NOTES

ADDITIONAL INFORMATION

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SODIUM BORATE, DECAHYDRATE

ICSC: 0567

Peer-Review Status: 11.04.2014 Validated

Disodium tetraborate decahydrate
Sodium tetraborate decahydrate
Sodium pyroborate decahydrate
Borax

CAS #: 1303-96-4 RTECS #: VZ2275000
EC #: 005-011-01-1
EINECS #: 215-540-4

Formula: $B_4O_7Na_2.\ 10H_2O$
Molecular mass: 381.4

TYPES OF HAZARD / EXPOSURE	ACUTE HAZARDS / SYMPTOMS	PREVENTION	FIRST AID / FIRE-FIGHTING
FIRE	Not combustible.		In case of fire in the surroundings, use appropriate extinguishing media.
EXPLOSION			
EXPOSURE		**PREVENT DISPERSION OF DUST! STRICT HYGIENE!**	
Inhalation	Cough. Sore throat.	Use local exhaust or breathing protection.	Fresh air, rest.
Skin	Redness.	Protective gloves. Protective clothing.	Rinse and then wash skin with water and soap.
Eyes	Redness. Pain.	Wear safety spectacles or eye protection in combination with breathing protection.	Rinse with plenty of water (remove contact lenses if easily possible).
Ingestion	Nausea. Vomiting. Diarrhoea. Headache. Weakness. Drowsiness. Convulsions.	Do not eat, drink, or smoke during work.	Rinse mouth. Do NOT induce vomiting. Refer for medical attention .

SPILLAGE DISPOSAL

Personal protection: particulate filter respirator adapted to the airborne concentration of the substance. Sweep spilled substance into covered containers. If appropriate, moisten first to prevent dusting. Carefully collect remainder. Then store and dispose of according to local regulations.

PACKAGING & LABELLING

EC Classification
R: 60-61; S: 53-45; Symbol: T
UN Classification

GHS Classification
Signal: Danger
Causes eye irritation
May damage fertility or the unborn child

EMERGENCY RESPONSE	SAFE STORAGE
	Well closed. Dry.

IMPORTANT DATA

Physical State; Appearance
WHITE CRYSTALS OR CRYSTALLINE POWDER.

Physical dangers

Chemical dangers
The solution in water is a weak base.

Occupational exposure limits
TLV (inhalable fraction): 2 mg/m³ as TWA; 6 mg/m³ as STEL; A4 (not classifiable as a human carcinogen); (ACGIH 2014).
MAK (inhalable fraction): 0.75 mg/m³; Peak limitation category: I(1); Pregnancy risk group: C; (DFG 2013).

Routes of exposure
The substance can be absorbed into the body by inhalation and by ingestion.

Inhalation risk
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly , especially if powdered.

Effects of short-term exposure
The substance is irritating to the eyes, skin and respiratory tract. The substance may cause effects on the central nervous system and kidneys. This may result in impaired functions.

Effects of long-term or repeated exposure
Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the testes. Animal tests show that this substance possibly causes toxicity to human reproduction or development.

PHYSICAL PROPERTIES	ENVIRONMENTAL DATA
Boiling point: see Notes Melting point: see Notes Relative density (water = 1): 1.7 Solubility in water, g/100ml at 20°C: 5.1	The substance is harmful to aquatic organisms.

NOTES

At 75 °C the substance loses crystal water. The anhydrous form has a melting point of 742 °C and decomposes at 1575 °C.

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SALICYLIC ACID

ICSC: 0563

Peer-Review Status: 04.11.1997 Validated

2-Hydroxybenzoic acid
o-Hydroxybenzoic acid

CAS #: 69-72-7 RTECS #: VO0525000
EINECS #: 200-712-3

Formula: $C_7H_6O_3$ / HOC_6H_4COOH
Molecular mass: 138.1

TYPES OF HAZARD / EXPOSURE	ACUTE HAZARDS / SYMPTOMS	PREVENTION	FIRST AID / FIRE-FIGHTING
FIRE	Combustible.	NO open flames.	Use water spray, carbon dioxide, powder.
EXPLOSION	Finely dispersed particles form explosive mixtures in air.	Closed system, ventilation, explosion-proof electrical equipment and lighting. Prevent deposition of dust.	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		**PREVENT DISPERSION OF DUST!**	
Inhalation	Cough. Sore throat. See Ingestion.	Use local exhaust or breathing protection.	Fresh air, rest. Refer for medical attention.
Skin	Redness.	Protective gloves.	Remove contaminated clothes. Rinse and then wash skin with water and soap.
Eyes	Redness. Pain.	Wear safety goggles or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then refer for medical attention.
Ingestion	Nausea. Vomiting. Ringing in the ears.	Do not eat, drink, or smoke during work.	Rinse mouth. Induce vomiting (ONLY IN CONSCIOUS PERSONS!). Refer for medical attention .

SPILLAGE DISPOSAL	PACKAGING & LABELLING
Personal protection: P2 filter respirator for harmful particles. Sweep spilled substance into covered containers. If appropriate, moisten first to prevent dusting.	**EC Classification** **UN Classification** **GHS Classification**

EMERGENCY RESPONSE	SAFE STORAGE
NFPA Code: H0; F1; R0.	Separated from strong oxidants.

IMPORTANT DATA

Physical State; Appearance
NEEDLE-SHAPED CRYSTALS OR COLOURLESS CRYSTALLINE POWDER.

Physical dangers
Dust explosion possible if in powder or granular form, mixed with air.

Chemical dangers
The solution in water is a weak acid. Reacts with strong oxidants.

Occupational exposure limits
TLV (NOT-ESTABLISHED):.

Routes of exposure
The substance can be absorbed into the body by inhalation and by ingestion.

Inhalation risk
Evaporation at 20°C is negligible; a nuisance-causing concentration of airborne particles can, however, be reached quickly when dispersed.

Effects of short-term exposure
The substance is irritating to the eyes, skin and respiratory tract. The substance may cause effects on the central nervous system and acid-base balance in the body. This may result in delirium and tremors.

Effects of long-term or repeated exposure
Repeated or prolonged contact with skin may cause dermatitis.

PHYSICAL PROPERTIES

Sublimation point: 76°C
Melting point: 159°C
Relative density (water = 1): 1.4
Solubility in water, g/100ml at 20°C: 0.2
Vapour pressure, Pa at 130°C: 114
Relative vapour density (air = 1): 4.8
Flash point: 157°C
Auto-ignition temperature: 540°C
Octanol/water partition coefficient as log Pow: 2.2

ENVIRONMENTAL DATA

NOTES

Volatility becomes noticeable above 50-60°C.
Anyone who has shown aspirin sensitization should never come in contact with this substance.

ADDITIONAL INFORMATION

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HYDROGEN CHLORIDE

(cylinder)

ICSC: 0163

Peer-Review Status: 03.11.2016 Validated

Anhydrous hydrogen chloride
Hydrochloric acid, anhydrous

CAS #: 7647-01-0 RTECS #: MW4025000
UN #: 1050
EC #: 017-002-00-2
EINECS #: 231-595-7

Formula: HCl
Molecular mass: 36.5

TYPES OF HAZARD / EXPOSURE	ACUTE HAZARDS / SYMPTOMS	PREVENTION	FIRST AID / FIRE-FIGHTING
FIRE	Not combustible.		In case of fire in the surroundings, use appropriate extinguishing media.
EXPLOSION			In case of fire: keep cylinder cool by spraying with water. Combat fire from a sheltered position.
EXPOSURE		**AVOID ALL CONTACT!**	**IN ALL CASES CONSULT A DOCTOR!**
Inhalation	Cough. Sore throat. Burning sensation. Shortness of breath. Laboured breathing.	Use ventilation, local exhaust or breathing protection.	Fresh air, rest. Half-upright position. Artificial respiration may be needed. Refer immediately for medical attention.
Skin	Redness. Pain. Serious skin burns. ON CONTACT WITH LIQUID: FROSTBITE.	Cold-insulating gloves. Protective clothing.	Wear protective gloves when administering first aid. First rinse with plenty of water for at least 15 minutes, then remove contaminated clothes and rinse again. Refer immediately for medical attention.
Eyes	Redness. Pain. Blurred vision. Severe burns. ON CONTACT WITH LIQUID: FROSTBITE.	Wear face shield or eye protection in combination with breathing protection.	Rinse with plenty of water for several minutes (remove contact lenses if easily possible). Refer immediately for medical attention.
Ingestion			

SPILLAGE DISPOSAL

Evacuate danger area! Consult an expert! Personal protection: gas-tight chemical protection suit including self-contained breathing apparatus. Ventilation. Remove gas with fine water spray.

PACKAGING & LABELLING

EC Classification
Symbol: T, C; R: 23-35; S: (1/2)-9-26-36/37/39-45
UN Classification
UN Hazard Class: 2.3; UN Subsidiary Risks: 8
GHS Classification
Signal: Danger
Contains gas under pressure; may explode if heated
Toxic if inhaled
Causes severe skin burns and eye damage
May cause respiratory irritation

	See Notes 

EMERGENCY RESPONSE	SAFE STORAGE
NFPA Code: H3; F0; R1.	Cool. Fireproof if in building. Separated from food and feedstuffs and incompatible materials. See Chemical Dangers. Keep in a well-ventilated room.

IMPORTANT DATA

Physical State; Appearance
COLOURLESS COMPRESSED LIQUEFIED GAS WITH PUNGENT ODOUR.

Physical dangers
The gas is heavier than air and may accumulate in lowered spaces causing a deficiency of oxygen.

Chemical dangers
The solution in water is a strong acid. It reacts violently with bases and is corrosive. Reacts violently with oxidants. This produces toxic gas (chlorine - see ICSC 0126). Attacks many metals in the presence of water. This produces flammable/explosive gas (hydrogen - see ICSC 0001).

Occupational exposure limits
TLV: 2ppm (ceiling value); A4 (not classifiable as a human carcinogen); (ACGIH 2014).
MAK: 2 ppm, 3.0 mg/m³; Peak limitation category: I(2); Pregnancy risk group: C; (DFG 2004).

Routes of exposure
Serious local effects by all routes of exposure. The substance can be absorbed into the body by inhalation.

Inhalation risk
A harmful concentration of this gas in the air will be reached very quickly on loss of containment.

Effects of short-term exposure
Rapid evaporation of the liquid may cause frostbite. The substance is corrosive to the eyes, skin and respiratory tract. Inhalation of this gas may cause asthma-like reactions (RADS). Exposure could cause asphyxiation due to swelling in the throat. Inhalation of high concentrations may cause lung oedema, but only after initial corrosive effects on the eyes and the upper respiratory tract have become manifest. Inhalation of high concentrations may cause pneumonitis. See Notes.

Effects of long-term or repeated exposure
Repeated or prolonged inhalation may cause effects on the teeth. This may result in tooth erosion. The substance may have effects on the upper respiratory tract and lungs. This may result in chronic inflammation of the respiratory tract and reduced lung function . Mists of this strong inorganic acid are carcinogenic to humans. See Notes.

PHYSICAL PROPERTIES	ENVIRONMENTAL DATA
Boiling point: -85.1°C Melting point: -114.2°C Density (gas): 1.00045 g/l Solubility in water, g/100ml at 30°C: 67 (moderate) Relative vapour density (air = 1): 1.3 Octanol/water partition coefficient as log Pow: 0.25	

NOTES

The occupational exposure limit value should not be exceeded during any part of the working exposure.
The symptoms of lung oedema often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation are therefore essential.
IARC considers mists of strong inorganic acid to be carcinogenic (group 1). However there is no information available on the carcinogenicity of other physical forms of this substance. Therefore no classification for carcinogenicity under GHS has been applied.
Turn leaking cylinder with the leak up to prevent escape of gas in liquid state.
Other UN number(s) 2186 (refridgerated liquid) hazard class: 2.3; subsidiary hazard: 8; 1789 (hydrochloric acid) hazard class: 8, pack group II or III.
Aqueous solutions may contain up to 38% hydrogen chloride.

ADDITIONAL INFORMATION

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