THE SCIENCE OF SAFETY:
Anti Fog Formulation

Understanding how an anti fog works, why it fails, and ways to choose an anti fog for performance

70% of safety professionals confirm a fogging problem. **Why don't companies provide an anti fog?**

In a study at the 2009 National Safety Council Congress and Expo, fielded by Nanofilm, maker of Defog It™ anti fog, 70% of safety professionals surveyed stated they either manage or specify products for people who have a problem with fogged safety glasses or safety goggles or have a workplace safety fogging problem themselves. Yet, fully two-thirds of them say they don't provide anti fog treatments that could solve this issue.

Moreover, the research is also clear on the impact of anti fog in increasing compliance with safety eyewear guidelines. In a study published in Accident Analysis & Prevention Magazine, over 55% of research respondents suggested an anti fogging solution to increase usage of personal protective eyewear. It was named by more focus groups than incentives, warning signs, eyewear cleaning stations or as a condition of employment.

There is anti fog protection for tough workplace conditions.

Why isn't anti fog available in every workplace where heat, cold, changing temperatures, humidity and exertion create fogged safety eyewear? The general excuses often heard are: "It never works."; "It's ok for general use, but not reliable for our environment."; "It only works for about 10 minutes."

Today's science changes all that. Not all anti fogs are alike. Cutting edge research at Nanofilm has resulted in the development of high performance anti fog formulations that help improve workplace safety in all kinds of work environments.

This article is intended to help the reader better understand the root causes of fog, how anti fog works, what causes them to fail, and how to choose the appropriate anti fog for the protective eyewear worn in any given work situation.

What causes fogging?

1. Humidity is the culprit. To better understand how safety glasses and safety goggles fog and how to prevent it, let's start with a quick refresher of a high school science lesson. Ice, water and steam are just different states of the same substance: H_2O. In ice, a solid, the molecules are held tightly together, just vibrating in place. In a liquid, those molecules are rolling around each other, but still in a mass. But in a gas, like water vapor or steam, the water molecules are bouncing around freely. Water vapor in the air has another name, too: humidity.
So how does fog form?

2. The science of changing temperatures. If you're in a cold walk-in cooler wearing safety glasses and step out into a warm kitchen, the warmer air comes in contact with the cold lenses. When something warm touches something cool, the two surfaces try to reach an equilibrium temperature. The warm air gives up heat, which is energy. That means some of those water molecules don't have enough energy to stay in a gaseous state and downgrade into a liquid, forming tiny water droplet on the lens – what we call fog.

3. The role of body heat and exertion. There's a similar reaction (as above) when a person is working in a hot environment. Body heat warms the air in the space between the face and protective eyewear. When that warm air touches an ever-so-slightly cooler lens, it gives up heat energy to equalize the temperature of the two surfaces. There's not enough energy to keep the water in a gaseous state, so the molecules slow their motion, becoming fog droplets on the lens.

4. High humidity creates additional stress. Of course, the higher the humidity, the greater the fogging problem. If there's more moisture in the air, there's more water present that can be converted (or condensed) into visible droplets.

How does anti fog work?

An anti fog coating contains hydrophilic ingredients, that is, "water-loving" ingredients. They want to absorb water and spread it throughout the coated surface. That keeps water droplets from becoming big enough to be visible, or, in other words, big enough to be seen as fog.

The four reasons an anti fog can fail.

1. The fog itself washes the coating away. Like an ultra-thin, invisible sponge, an anti fog coating eventually becomes fully saturated with moisture. A sponge drips water out; but anti fog is literally washed away by the moisture it's absorbed, leaving safety eyewear unprotected.

2. There are not the correct water-loving ingredients in the formula. The type and amount of water-loving hydrophilics in the formula do matter. More hydrophilics can absorb more moisture. But there's another factor that may be even more important.

3. The anti fog never bonds to the lens.Some anti fog treatments are formulated to "stick" more tightly to the lens surface, so it takes more moisture to wash them away.

Let's pause for another science lesson. The lenses found in safety glasses and safety goggles are made of plastic materials like acrylic and polycarbonate. Some – especially prescription lenses – also have coatings on them, such as anti-glare, anti-scratch or easy-clean. All of these surfaces are hydrophobic, or "water-hating". It's not easy to get a "water-loving" hydrophilic coating to adhere to them. In scientific terms, the lenses have low surface energy. A coating, like anti fog, generally has a higher surface energy and doesn't bond strongly to it. To get the anti fog to bond, surface-active agents must be added to the formula to lower the surface energy level. Now let's complicate the problem even more.

4. The anti fog isn't matched to the lens material. There are dozens of different lens materials and coatings used on protective eyewear, each with its own surface energy level. The surface-active agents that promote bonding to one may not solve the problem on another.

What anti fog chemistry works?

1. Anti fog formulas that "stick." Research chemists have found that you can't get top performance from an anti fog with just a few agents to reduce the surface energy of the coating. There are so many lens materials used in eye protection that a narrow chemistry will work on one but not another. The solution is to formulate a synergistic blend of agents with different surface energies that work together to bridge the wide variety of lenses – and surface energies -- in the market.

2. A balanced approach. This approach carries an additional complication. The blend of so many surface-active agents can make the formula unstable and prone to breakdown. It's a complex chemical balancing act to get all these elements working together in a stable solution.

Is there a difference between liquid anti fog and anti fog cloths?

It's an additional technical achievement to get an anti fog liquid into a cloth. The interaction of a natural or synthetic cloth material requires another chemistry balancing act. The anti fog formula must bond to the cloth so it can be transferred to the lens. If the bond isn't strong enough, the solutions will transfer too quickly, leaving streaks. If the bond is too strong, it doesn't transfer smoothly – or at all – to the lens, so the coverage is spotty.

How can you test anti fog for optimum workplace safety?

Before you put anti fog into the field, consider performing these 20-minute tests in your own company kitchen that approximate lab tests by research scientists. If fog forms on the coated lens, you could have problems in the real world.

• Heat and humidity test

This measures the effect of heat and humidity on the coating.

1. **Select samples of the safety glasses or safety goggles you use in your workplace. If you have multiple types of lenses, test them all.**
2. **Apply anti fog to one lens and leave the other bare.**
3. **Hold the protective eyewear over a pot of boiling water for 30 seconds.**

• Heat and cold cycle testing

This simulates moving from hot to cold environments, such as working in commercial kitchens or the work pattern of people who move frequently from indoors to outdoors.

1. **Select samples of the safety glasses or safety goggles you use in your workplace. If you have multiple types of lenses, test them all.**
2. **Apply anti fog to one lens and leave the other bare.**
3. **Place the protective eyewear in the freezer for 5 minutes.**
4. **Take them out of the freezer and breathe on the lenses to see if fog forms.**
5. **Repeat 2 or 3 times.**

About Clarity Defog It Anti fog

Defog It anti fog multi-use cloths and liquid can keep optics fog-free up to all day with a single application. The formula is used by militaries around the world to prevent fogged protective eyewear in vision-critical situations. It's tested safe and effective on safety glasses, safety goggles, faceshields and eyeglasses.

Defog It has been field tested and proven by organizations with identified fogging issues, including global pulp and paper producers, utility companies, the National Tactical Officers Association Members, the U.S. Coast Guard, the National Ski Patrol and major U.S. mining organizations. In each case, users reported the improved vision clarity that promotes usage of protective eyewear and safety in the workplace.

The product has been rigorously performance tested. In one test, a lens treated with Defog It was held over constant hot steam for 60 minutes without fog forming. Similar anti fog products failed in as little as 5 minutes. In another test, lenses coated with Defog It were moved between cold and hot environments 100 times without fog forming.
Nanofilm, founded in 1985, is a global optical leader in lens care and optical coatings. Millions of people around the world use Nanofilm products, including Clarity Defog It™, Clarity Clean It™ and other optical products, as well as nanotechnology-enabled coatings.

Additional Resources

National Institute of Occupational Health and Safety: *Toolbox Talk*
http://www.cdc.gov/niosh/topics/eye/toolbox-eye.html

Liberty Mutual Research Institute for Safety: *Eyewear in the Workplace, Examining Barriers to Use*
http://www.libertymutualgroup.com/omapps/ContentServer?c=cms_document&pagename=LMGResearchInstitute%2Fcms_document%2FShowDoc&cid=1239990441146

Centers for Disease Control and Prevention: *Eye Safety for Emergency Response and Disaster Recovery*
http://www.cdc.gov/niosh/topics/eye/eyesafe.html

Centers for Disease Control and Prevention: *Eye Protection for Infection Control*
http://www.cdc.gov/niosh/topics/eye/eye-infectious.html

Centers for Disease Control and Prevention: *Eye Safety Checklist*
http://www.cdc.gov/niosh/topics/eye/eyechecklist.html

Centers for Disease Control and Prevention: *Eye Safety*
http://www.cdc.gov/niosh/topics/eye/

Reducing Eye Injuries in the Workplace: *A Study of Personal Protective Eyewear and Antifog*
http://defogitworks.com/syncshow/uploaded_media/glmod_Modules_Knowledge-Center/Reducing_Workplacircbrvbares_research-1307655297.pdf

How to Improve Workplace Safety: *Seven Simple Best Practice Tips*
http://defogitworks.com/syncshow/uploaded_media/glmod_Modules_Knowledge-Center/Seven_Tips_on_Workplace_Eye_Safety-1307631132.pdf