Glass Dust Confusion: How the rescue community has been left in a cloud

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Since introducing a new motor vehicle glass-cutting device to the 1st responder community about a year ago, one of the top questions that invariably has been asked regardless of the country I am in is "What about the *glass dust?"* Many take the strong position that glass dust causes silicosis and lung cancer and that a respirator mask must be donned anytime glass is cut during extrication procedures. With extensive background as a forensic bioengineer and biomechanical engineer, I decided to investigate this issue in more detail to determine the validity of the claims against glass dust. What my research uncovered will likely be very hard for many to get their heads wrapped around considering several decades of training to the contrary. This article is intended to explain the results of that research effort in sufficient detail to convince many who will be skeptical. In the end, the rescue and extrication community, including FIRE, EMS and POLICE, must come to terms with the fact that way too much time has been wasted for a hazard that does not pose an unreasonable risk.

First - some background information.

Let's start with the basics… glass is a hard, brittle substance, typically transparent or translucent, made by mixing and heating sand or silica with soda, lime, and other ingredients.[1] The molten mixture is rapidly cooled using controlled processes to make windows, drinking containers, vases and other products.

Glass that is classified as *safety glass* has been toughened to provide increased resistance to impact or shattering into large, dangerous shards which can injure nearby persons. Safety glass comes in two basic types: *tempered* and *laminated*. Annealed glass is tempered by subjecting it to rapid, controlled cooling to produce compressively-stressed surface layers which increase its strength compared with normal glass.[2] Tempering creates balanced internal tensile stresses which cause the glass to crumble into small granular chunks when shattered instead of splintering into long, jagged shards. The granular chunks are less likely to cause injury. See Figure 1.

Laminated glass is a type of safety glass which is assembled using two or more glass sheets bonded together at high pressure and elevated temperature with one or more ~~an~~ interlayers to form a clear, see-through barrier with enhanced impact and shatter resistance.[3] Polyvinyl butyral (PVB) plastic is commonly used as the interlayer which further enhances the glass by increasing sound insulation, minimizing vandalism, permitting tinting and blocking nearly 99% of ultraviolet radiation. With sufficient impact force, the glass layers will shatter into the characteristic "spider web" cracking pattern creating granular glass fragments. The

PVB interlayer functions to hold the glass fragments together, minimizing the risk of flying glass impacting people.

Almost all modern motor vehicles around the world are required to have some form of safety glass for windows. Here in the U. S., laminated glass has been standard in automobile windshields since as early as the 1920's. However in March of 2011, the U.S. Code of Federal Regulations Title was amended to mandate all U.S. motor vehicles alter airbag and/or side window design to minimize the risk of occupant ejection by 2017.[4] Until this recent change, tempered glass has been commonly used for all side and rear vehicle windows.

Description of the problem

During rescue operations, motor vehicle glass must be forcibly removed to gain access to injured occupants or for further extrication procedures. Current glass cutting tools are shown in Figure 2. The use of these glass-cutting hand tools generates glass debris which can range in size from powder to pea size particles. This debris may be small enough to become airborne and may be respired or breathed into the lungs of rescue workers. It is widely believed in the extrication community that this airborne glass dust is very dangerous and causes silicosis, lung cancer and other respiratory disorders.

When did glass dust become such a big deal?

An effort was undertaken to determine when this issue first began to arise in the extrication community using a literature review of extrication manuals, textbooks, and journal articles and magazine articles. Based upon this review, the timeframe of early-2000's was when glass dust began making its way into the extrication industry discussion. Below is a timeline of references reviewed:

1969 – *Extrication of Trapped Casualties: Road Accidents and the Family Doctor* by R. Snook – extrication procedures and equipment discussed - no mention of glass dust or dust masks.[5]

1975 – *Vehicle Rescue: A System of Operations* by Harvey Grant – eye/face protection from glass impact was discussed during vehicle glass removal.[6]

1987 – *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program* by NFPA – "The link between respiratory and heart diseases and fire service careers has been well documented and established." Fire Departments must provide respiratory protection (no mention of glass dust or filter mask requirements). All respiratory references SCBA.[7]

1991 – *Vehicle Extrication: A Training Manual* by Kidd and Cjajkowski – implore readers to wear PPE including head, eye, hand and foot protection – no mention of glass dust.[8]

1991 – *Vehicle Rescue and Extrication* by Ronald E. Moore – Discussion of glass removal contained no references to dust, silica or respiratory masks.[9]

1992 – *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program* by NFPA – "When operating in the hazardous area at an emergency scene without the full facepiece of SCBA being worn, members shall deploy the helmet face shield or partial face protection." The term "particulates" is first used in this standard regarding protective garments.[10]

1994 – *New Technologies In Vehicle Extrication Equipment* by U.S. FEMA – literature review and extensive fire industry survey of current extrication equipment – neither review or survey list any glass dust issues or concerns. [11]

1997 – *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program* by NFPA – Same as 1992 – addition discussion of firehouse diesel particulates.[12]

2000 – *Principles of VEHICLE EXTRICATION* by IFSTA and Carl Goodson – both extrication personnel and victims must be protected from glass dust and chips produced during the cutting operation. Glass dust text was with regard to impact not respiration.[13]

2001 – Enhanced Protective Glass in Vehicle Extrication by R Shaw and J Onder – "…when removing any glazing, wear proper personal protective equipment, including eyewear and a dust mask."[14]

2002 – *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program* by NFPA – "Examples are filter respirators, chemical cartridge or canister respirators, airline respirators, powered air-purifying respirators, and self-contained breathing apparatus." Filtering masks are addressed with regard to chemical and biological terrorism. Particulates verbiage same as 1997.[15]

2003 – *Vehicle Rescue and Extrication – 2nd Ed.* by Ronald E. Moore – "…Progressive vehicle rescue agencies also require that their crew members wear disposable dust masks over their mouths and noses when removing laminated safety glass…"[16]

2005 – *Vehicle Extrication: A Practical Guide* by Brian G. Anderson – wear appropriate PPE and avoid inhaling the glass dust by mouth or nose.[17]

2005 – *Extrication of the seriously injured road crash victim* by V. Calland - reviews current safety concerns for extrication personnel and motor vehicle patients – no mention of glass dust as a safety concern.[18]

2005 – Glass dust - carcinogenic? by firehouse.com – "*In our county for as long as I can remember, the vehicle extrication courses have instructed students to wear dust masks while removing automotive window glass, both tempered and laminated due to the 'dust' being a carcinogenic*?..."[19]

2006 – HOLMATRO'S VEHICLE EXTRICATION TECHNIQUES: A guide to rescue tool handling and extrication techniques by Holmatro USA – "…Cutting glass and certain composite materials causes the release of fine particles that are hazardous if inhaled. Using a filtration mask when working on these materials is recommended…"[20]

2006 – Would breathing in glass dust shred your lungs? by unknown – *"Glass dust causes silicosis, which can be a very serious disease, especially if it happens over a long period of time. Lots of miners die of this. Your lungs have trouble getting the glass dust out, so it and its effects accumulate over time…"*[21]

2007 – *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program* by NFPA – same as 2002 plus NIOSH-approved Type C respirators required for all emergency medical care firefighters to meet 42 CFR 84 Approval of respiratory protective devices for airborne infectious diseases, liquid splash incidents and technical rescue operations. Added definition of particulate.[22]

2009 – Beware of Glass Dust by unknown – "…I was told - from grinding glass all day for years and not wearing a mask - she now has lung cancer from all the glass dust. She even had water trickling over the glass while she was grinding / engraving ... I guess it wasn't enough. It was a sad thing to hear - she's only in her 50's.[23]

2009 – Extrication Tips: Raising the roof - Laminated glass removal poses significant danger by Randy Schmitz – Glass dust or crystalline silica is very hazardous and an N95 mask should be used at all times when cutting motor vehicle glass.[24]

2013 – How concerned should I be about glass dust? by unknown – questions whether glass dust is dangerous.[25]

2013 – *NFPA 1500 Standard on Fire Department Occupational Safety and Health Program* by NFPA – same as 2007[26]

This is where the confusion started – crystalline v. amorphous silica dioxide.

Although some cursory discussion of particulates began in the early 2000's, and Ron Moore's 2003 textbook states some "progressive" extricators are required by their fire departments to wear dust masks, the 2009 article entitled *Extrication Tips: Raising the roof - Laminated glass removal poses significant danger*[24] appears to be one of – if not the first in the extrication literature to address and evaluate glass dust with its chemical name silica. The author, Randy Schmitz reported on an observation he made while serving as a TERC judge at a competition where the windshield was cut during a scenario and he observed the following: "…Everywhere I looked, for at least a 15-square-metre radius, were fine particles of glass dust that would not dissipate..." Schmitz then reports the results of his research into glass dust which included a Material Safety Data Sheet (MSDS) for ***respirable crystalline silica*** which is classifies as hazardous to humans. Unfortunately, Schmitz's research failed to discover that although glass dust is 70-75% silica, it is not in the form of crystalline silica.

As discussed earlier, glass is manufactured using sand, otherwise known by its chemical name "silica dioxide." Silica dioxide has two forms: ***crystalline*** and ***amorphous***. It turns out that ***crystalline silica dioxide*** is hazardous to breathe and is well documented to cause silicosis and a myriad of respiratory disorders.[27] Glass dust however is not crystalline silica dioxide but ***amorphous silica dioxide***. As with many situations, the devil is in the details… here's a closer look.

A crystal is a solid material which occurs naturally during cooling from its melting point where its molecules align in a very regular and organized manner. The resulting solid is a homogeneous solid with geometrically arranged plane faces. See figure 3. Respirable crystalline silica dioxide is most frequently found in metal, non-metal and coal mines and mills;

in granite quarrying and processing, crushed stone and related industries; in foundries; in the ceramics industry; in construction and in sandblasting operations.

An amorphous solid material forms during the cooling process from its melting point. This causes the molecules of the material to become irregular and to have no alignment or arrangement. This difference in basic structure drastically reduces its toxicity in animals and humans. So much so that the US Food & Drug Administration have approved it for use as an anti-caking material for keeping foods like shredded cheese from sticking together.[28] Large quantities of synthetic amorphous silica are used, notably, for reinforcing elastomers, for thickening resins, paints and toothpaste, and as free-flow additives.

Is respirable glass dust cancer-causing?

The international group World Health Organization – International Agency for Research on Cancer published a review article in 1997 entitled *Monographs on the Evaluation of Carcinogenic Risks to Humans*.[29] The committee conducted an extensive review of all epidemiological research studies regarding crystalline and amorphous silica dioxide and concluded the following:

- Crystalline silica inhaled is carcinogenic to humans.
- Amorphous silica is not classifiable as to its carcinogenicity to humans.

A second committee in 2011 published a similar review article on crystalline silica and stated:[30] "Through extensive review of the published literature, two independent expert panels convened by the International Agency for Research on Cancer (IARC) Monographs Programme have classified crystalline silica as carcinogenic to humans while amorphous silica was not classifiable as to its carcinogenicity in humans. The panel remarked that crystalline silica in the form of quartz or cristobalite dust causes lung cancer in humans."

Another extensive review article published in 2012 entitled *The toxicological mode of action and the safety of synthetic amorphous silica—A nanostructured material* states:[31] "… amorphous silicas… have widely been used in topical and oral medicines, food and cosmetics for decades without evidence of adverse human health effects." And, "In contrast to crystalline silica, SAS [synthetic amorphous silicas] slowly dissolves in aqueous environments and body fluids. None of the SAS types was shown to bioaccumulate and all disappear within a few weeks from living organisms by physiological excretion mechanisms."

Currently, bioengineers and doctors have been working together extensively to develop effective drug delivery methods utilizing amorphous silica nanoparticles. These studies include respiratory and direct implant studies.

The bottom line.

Currently, there is a huge disconnect between the extrication/rescue community and other groups like the medical device/drug delivery industry, the food industry and OSHA when it comes to silica dust. While rescue workers potentially loose valuable seconds dealing with a non-issue like glass

dust, medical device firms and food and cosmetic manufacturers are purposely using glass dust particles to make their products – some with respirable applications!

After delving into the extrication literature, observing rescue challenge competitions and speaking at length with many extrication experts and 1st responders including FIRE, EMS and POLICE, it is clear that extrication procedures have been altered to accommodate this counterfeit hazard. One could easily envision that if this issue was to quickly become a non-issue, wouldn't each individual extrication become a little less complicated… a little more straightforward? One thing is certain, with the recent changes in US motor vehicle glass standards scheduled to take effect by late 2017, extrication procedures will have to change to meet the new challenges with patient access with laminated glass in all portals? It is my hope that this information will be used to begin the process for positive change for every future crash.

(a) Tempered glass (b) Laminated glass

Figure 1. Shattered motor vehicle glass.

Figure 2. Current glass management hand tools.

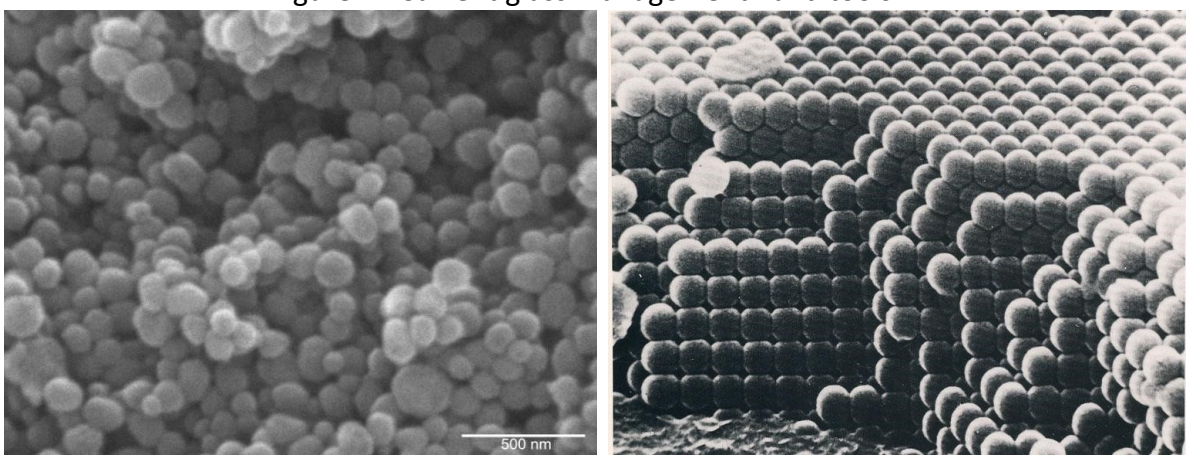

Figure 3. Amorphous v. Crystalline arranged materials.

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