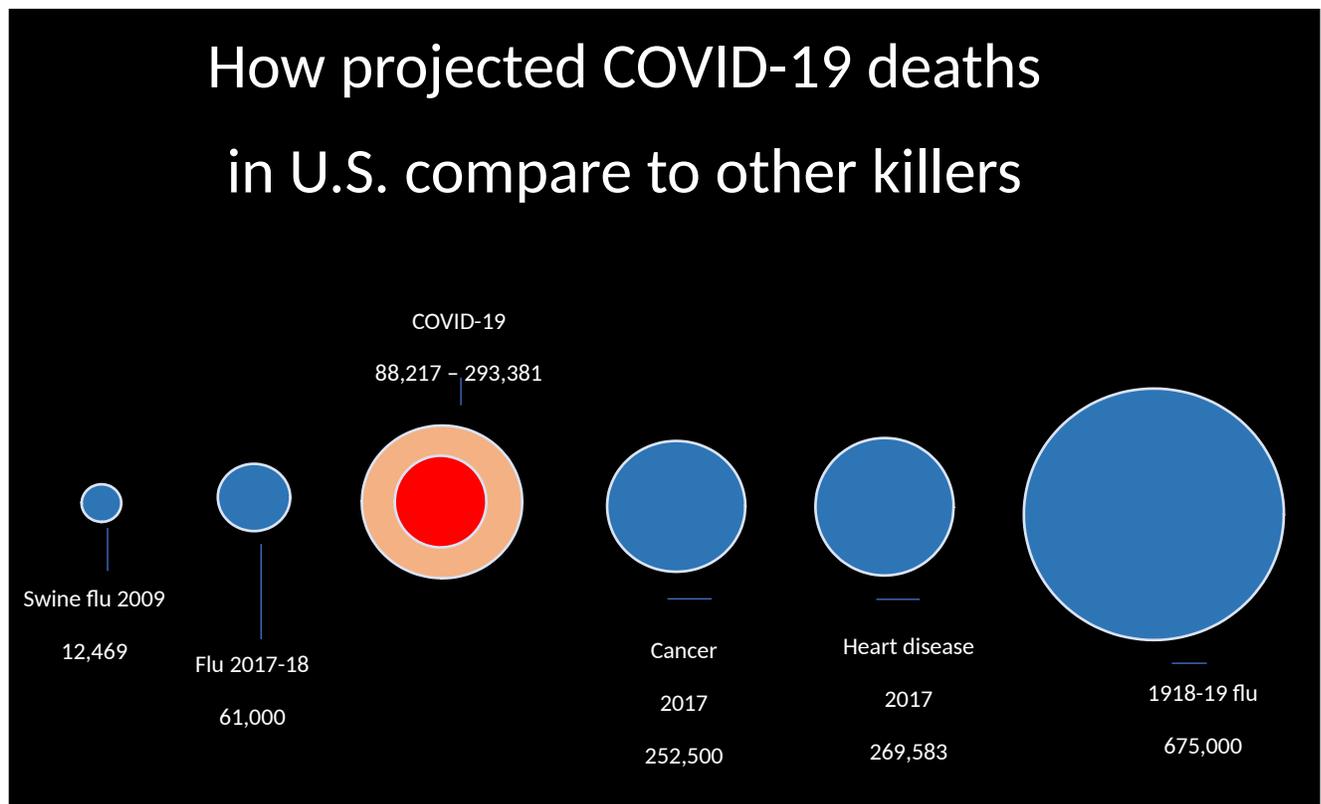


Keeping COVID-19 off the Production Line

by Steve Stach

Surprise, look who just showed up and changed our lives and how we manufacture our products. It is estimated by years end that the COVID-19 virus will take a million lives worldwide and the total economic impact could be in the tens of trillions of dollars in the United States alone. This is a game changer.

One of the better recognized independent models, created by Youyang Gu, estimates the deaths in the U.S. this year would range between 88,217 and 293,381. How serious is it? To put this in perspective, the pandemic has already taken tens of thousands of lives and has the potential to kill more Americans than cancer or heart disease has in recent years.



The projected economic impact will be enormous. In a recent report produced by Oxford Economics, the researchers project a 7% drop in world GDP in the first half

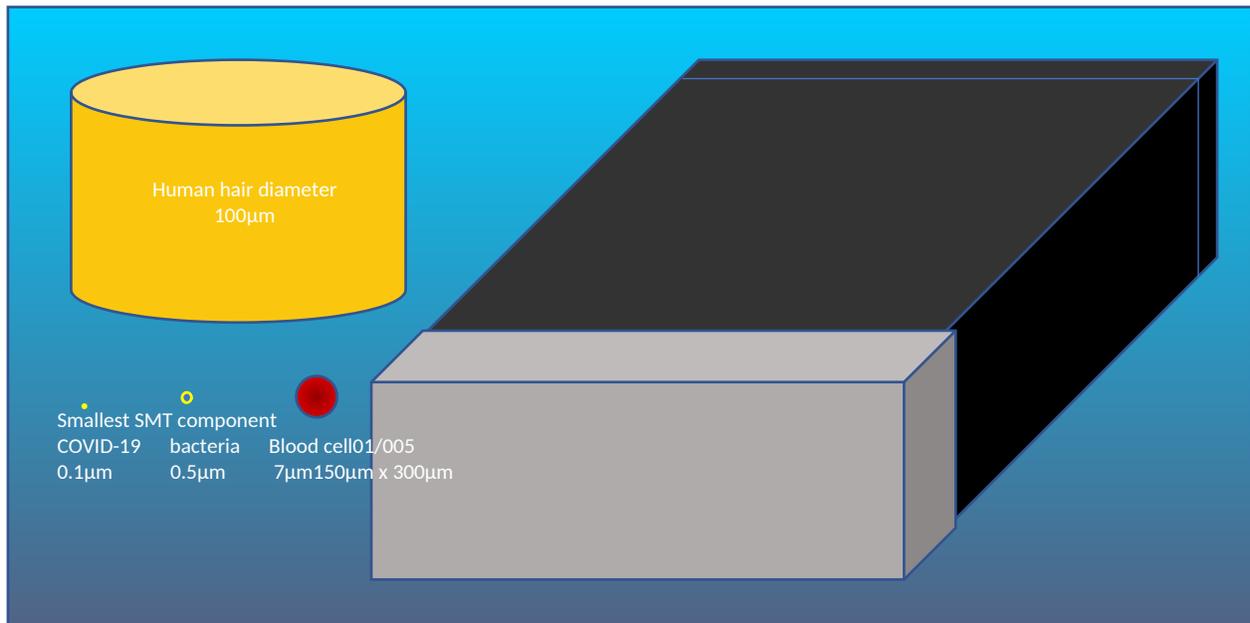
of the year, and a 3% shrinkage year to year. Some say this is optimistic. Manufacturing is a key component of the world economy and provides much of the capital that feeds the service sectors. The economic effects of manufacturing are multiplied through economies worldwide.

The bureau of Labor Statistics reports there are 12.85 million manufacturing jobs in the U.S. making up 8.5% of the total workforce. These jobs pay 12% more on average. With so many people working on product production lines, there is a huge need to protect the places we work and to provide a product free of Coronavirus risk to our customers. Just about all of us have been issued stay at home orders, face mask use, hand sanitizer and told not to gather in large crowds. Protection is also needed for production lines which are critical in maintaining our supply lines, infrastructure, jobs, and economy. As with protecting your family at home, the answer starts with understanding the virus and the role people and materials play in its transmission paths.

The Virus

Scientific American magazine reports the COVID-19 virus most likely jumped from bats to humans, in Wuhan, China in late 2019. Bats are known to carry hundreds of corona virus species. The family of corona viruses are so named for the corona like projections that emanate from its mostly round body. Well known relatives include the MERS, and SARS viruses. Although it may not be as lethal as some of its cousins, it is much more contagious, spreading around the world in just a few short months by human contact and airborne viral particles.

A single virus measures only 50-200 nm across. In real world measurements, it would take more than 1000 single viral particles called virions to make a single ring around a human hair. Because of this, thousands of viral units could be transferred by a single cough or touch to the nose. Under normal circumstances, contact with a single virus will not make you sick because our natural barriers like skin, hair, and mucus stop most viruses before they implant in the body.



Size comparison of COVID-19 virus

The concentration of viral particles in bodily fluid is called the titer. Harvard Medical School said that new evidence indicates that the titer is sufficient to transmit the disease 2-3 days before symptoms appear.

These particles can remain viable at room temperature and are capable of infecting others anywhere from hours to a week depending on conditions and the surface it resides on.

New studies suggest more than half of the cases of infections detected by antibody testing showed no signs of infection. Reuters reported that 60% of personnel aboard the aircraft carrier Theodore Roosevelt, who tested positive for COVID-19, appeared healthy and showed no signs of infection.

Transmission Paths into and out of the Factory

People and materials are the primary transmission paths onto the manufacturing line. Both have been shown to transmit the virus with quite different timelines.

Sources of COVID-19 Transmission



Identify COVID-19 transmission paths

Airborne particles typically remain viable for up to a few hours, while viruses on certain surfaces can remain viable for several days. With the possible exception of bats, cats, and dogs, all known transmission of COVID-19 has occurred from infected humans as the source. The primary method of transmission is either by breathing airborne particles or by transferring the virus from a contaminated surface to the mouth, nose, or eyes. The CDC reports viable COVID-19 virus is found in bodily fluids including sputum from the upper and lower respiratory tract, blood, and stool samples. It is not yet known if other non-respiratory body fluids from an infected person, including vomit, urine, breast milk, or semen can contain viable infectious COVID-19 virions.

Materials can become contaminated by infected humans and can remain contagious for days. This is very dependent on the material and the environmental conditions. The New England Journal of Medicine and a recent Lancet Microbe study indicates the COVID-19 virus can remain viable on paper money, glass, plastic, and most metals, for up to four days. Surfaces like copper or silver and other materials like cardboard killed the virus faster.

Surface	time to ND
Paper	3 hrs
Copper	3 hrs
Cloth	2 days
Wood	2 days
Glass	4 days
Paper money	4 days
Stainless Steel	7 days
Face mask	7+ days

Virus survivability on various surfaces

These tests were performed at ambient conditions. Other studies suggest that this time is cut short if the temperature is increased.

Site Plan

Each manufacturing site should have a pandemic plan to protect employees, customers, and vendors health, as well as the business. Companies that do not have a pandemic plan are creating one. Companies that have a plan are updating it. Plans reveal how your site would manage the health and safety of people in a pandemic like the COVID-19 outbreak. It should address other anticipated items like supply chain disruptions and personnel shortages. The IPC has issued a Special Report on COVID-19 and best practices for worker health. It is available on the IPC web site.

Check People Before They Enter the Factory

One of the best ways to keep the virus out of the factory is to check the people coming into the factory. This includes everyone- workers, management, vendors, contractors, friends, and family. No one should be exempted. Screening should include a body temperature scan, and a physical inspection, do they look sick? Each person should be asked if they have been exposed to anyone who has the virus or if they have had any COVID-19 symptoms in the last few weeks. If the answer is yes to any of the questions, they should be temporarily denied access. Just remember, a large percentage of infected people can carry the virus and never show symptoms or, can be contagious prior to showing symptoms.

Social distancing rules of one-meter minimum separation should be maintained whenever possible. This screening process should continue until 60% or more of a population is immune by surviving the virus or by receiving immunity through a vaccine.

Because we are uncertain of who may be spreading the virus, it is essential that each person should have the basic personal protective equipment *before* entering the production area. Once people in the factory have become infected, contact tracing and isolation is the best current method of preventing spread.

Personal Protective Equipment for Production

More protection is needed at work than at home because of a combination of greater exposure risk and higher economic consequences. An outbreak on the line could jeopardize human health, stop production, and send everyone home for a quarantine time of up to two weeks. A chronic ongoing corona infection could cripple a manufacturing company. At home, soap and water and a face covering will usually get us through the day safely.

In the factory, we may not be able to wash our hands every time we handle materials and product. Gloves, hand sanitizers, and conductive finger cots allow us to touch people and materials safely and should be an essential part of a production line PPE. PPE that contacts circuitry such as gloves or finger cots should be ESD safe. Hand lotions are not recommended on the production line. Shoe coverings can keep the floors cleaner if practical.

All masks are not created equally

Face masks are an essential part of the COVID-19 PPE arsenal. Face covering comes in all sizes and shapes. They have been shown to minimize the airborne particles generated when we breath, talk, cough and sneeze. Some are homemade while others meet very stringent requirements. N-95 and level 1-3 ASTM masks, provide filtration levels sufficient to block most viral particles.

	N-95	ASTM level 3	ASTM level 2	ASTM level 1	Low level	Bandana
Bacterial filtration Efficiency (BFE)	95.0% @ 0.1 micron	99.9% @ 3.0 micron	99.9% @ 3.0 micron	98.4% @ 3.0 micron	99% @ 4.0 micron	40% @ 3.0 micron
Particle Filtration Efficiency (PFE)	99.9% @ 0.1 micron	99.8% @ 0.1 micron	99.7% @ 0.1 micron	95.0% @ 0.1 micron	90% @ 0.5 micron	20% @ 0.1 micron

A comparison of face mask performance

Coronavirus particles range in size from 0.05µm to 0.20 µm. The fit of the mask to the face is very important. A poorly fitting mask is ineffective. A new face mask should be issued every day. Soiled masks should be properly discarded.

The Effects of Temperature on the Virus

Newsweek reported that a new study indicates the COVID-19 virus can survive for one hour at 60 degrees Centigrade (140 Fahrenheit). They went on to report that it took an exposure of 15 minutes at 92 Centigrade (194 Fahrenheit) to kill certain strains of the virus. In a report published by Lancet Microbe, the virus was reported very stable at 4 degrees Centigrade and therefore could remain viable for much longer periods of time.

Temp.	time to not detectable
4C	14+days
22C	14 days
37C	2 days
56C	30 mins
70C	10 mins

Time required to kill COVID-19 at various temperatures

COVID-19 Sanitizers for People and the Facility

There are many types of sanitizers. In general, they are broken into 3 categories; for humans, for the facility, for the product. Various commercial formulations are available for disinfecting people and materials from the Coronavirus. A full list of EPA approved disinfection chemicals can be found on the EPA web site.

Facility sanitization should be put on a regular schedule and should include production, cafeteria, and restrooms. Air handling systems should be kept in tip top condition to minimize airborne particulates.

Hand sanitizers come in two types, alcohol based and non-alcohol formulas. The non-alcohol formulas generally rely on water with a quaternary ammonium salt. Alcohol based hand sanitizing formulas use either ethyl or isopropyl alcohol.

The World Health Organization recommends alcohol-based hand sanitizers with at least 70% alcohol. Non-alcohol-based sanitizers are not proven as effective on corona virus as the alcohol containing formulas which kill the virus in less than one minute. Washing hands for one minute with soap and water is still considered the most effective method of hand sanitization.

Product Sanitization

Just ask the sales and marketing department and they will tell you the products need to be "COVID-19 Risk Free". This could be a crucial advantage in selling the products we produce in the foreseeable future. How can we assure our customers that the product they are buying will not make them sick or die?

Perhaps we can look to the medical industry as they deal with this all the time. How do they accomplish this with delicate surgical equipment and implantable devices? They use a variety of approaches using UV light, ethylene oxide gas, or nuclear irradiation. Although these methods are effective, they can be dangerous, complicated, and require a sizable capital investment and technical expertise to operate. A lot to ask for when we do not know the duration of the current problem.

A better approach for electronic manufacturers is to use existing processes and equipment to sanitize the product. Time, temperature, and production equipment can be used to sanitize circuit boards, tools and storage containers.

Existing circuit cleaning equipment and ovens can be drafted to disinfect product surfaces at incoming inspection, work in progress, and for the completed product.

Product Quarantine

Many studies show the COVID-19 virus cannot remain viable outside a host for more than a week at ambient conditions. So, the simplest way to remove the coronavirus risk is to quarantine the product before shipment for a minimum of 14 days at room temperature. Higher temperature quarantine can shorten the cycle but this requires continuous monitoring to certify the virus is killed.

Disinfecting Product with Existing Cleaning Equipment

Most circuit board manufacturers have cleaning equipment and testers on the production line that can be used to sanitize the tools and products.

Alcohol based systems require an exposure to a 70% IPA concentration or higher for one minute to kill the virus according to the WHO. Most circuit board tester/cleaners use a mixture of 70% to 99% solution of IPA with DI water. Circuit cleanliness testers may be limited in tank size because they are designed to test one circuit at a time. Other larger IPA cleaners that are used for pre-conformal coat and final cleaning in medical applications are available with larger tank capacities.



Photo of a high capacity alcohol-based circuit board cleaner

Water based cleaning systems are often used to clean flux and other contamination from circuit assemblies. These, too, can be utilized to kill and remove the virus on product and tooling. Water only cleaning system may remove the majority of virus contamination, but process temperature should exceed 65 C for more than 15 minutes to be considered effective in attenuating the virus. As reported earlier in this article, minimum process temperature of 92 C is required to kill the virus completely. This can occur in the wash or rinse or drying operation, but the drying cycle is preferred as it comes last and avoids recontamination possibilities.

Water based cleaning systems with cleaning agents can lower the temperature required to attenuate or kill the coronavirus. Soaps and detergents in water have been shown to kill the virus at room temperature with a short exposure time by attacking the lipid coating surrounding the virus. Many, but not all, aqueous based cleaning agents have surfactants that would attack the lipid shell. Contact your chemical supplier for more information on the specific product used on the production line. Bleach, ammonia, and other household disinfecting agents can harm electronic circuits and should not be used.

Summary and Conclusions

No one knows how long the COVID-19 pandemic will last or what the long-term economic effects will be. One thing that is for certain, factories that keep the virus off the production line will have an advantage over the ones that do not. This requires an understanding of how the virus works, lives, and dies. Manufacturers with a dedicated team and a focused plan will keep the COVID-19 virus off our production lines.

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