

# CASE STUDY: BELLEVILLE SPRINGS INSTRUMENTAL IN SUCCESSFUL DEPLOYMENT OF AIRCRAFT EMERGENCY EVACUATION CHUTES



## UNIQUE CHALLENGES FOR MACHINE ELEMENTS

There are many applications where Belleville springs can be stacked in arrangements to provide increased load and/or deflection, and used as a machine element — or the mechanical components of a machine. This type of application presents unique challenges that differ from bolting applications. Some of these include:

1. **Cyclical loading**— Bellevilles, like any highly stressed components, can be subject to fatigue failure in high cycle applications.
2. **Tolerance on loading or displacement**— Every component in a machine assembly has dimensional tolerances. This invariably leads to performance variation. The key is to understand acceptable limits of this variation and design springs to meet these requirements.
3. **Space constraints**— Bellevilles are often used when high loads are needed, and space is limited. It is critical to understand the envelope for any given design.
4. **Friction**— There is friction at all loading interfaces of a Belleville spring. This is especially true when springs are stacked in parallel. However, for each spring stacked in series, the contact is rolling, and friction is reduced. Tall stacks of springs also tend to buckle which can add to the friction.
5. **Design optimization**— For any design problem, there are often multiple solutions. For example, an application requires a linear displacement of .060" at 1000 lbs. and must fit into a 1.00-inch diameter cavity. We may be able to stack three springs that have 400 lb. flat loads in parallel to meet the loading and five sets in series to meet the deflection requirement. However, another possibility would be to stack six springs that have a 1200 lbf flat load in series. The latter is a much more efficient design because fewer parts and less space will be needed and so the cost per assembly will be reduced assuming other factors such as manufacturing steps are equal. An added benefit will be reduced friction and overall weight.
6. **Environment**— Elevated temperatures, cryogenic applications, and corrosive environments play a significant role in each design.



## AIRCRAFT SAFETY SYSTEM INFLATION EQUIPMENT

One application that considered all of these factors is for a pressure regulator that is integral for aircraft safety systems. The inflation equipment, manufactured by NMG Aerospace, is used to manage a steady flow of gas to ensure swift, proper inflation of aircraft evacuation slides in an emergency. A proprietary design comprised of a stack of Belleville springs are critical components in the regulators that regulate the flow and pressure of the ambient air that is forced to inflate the chutes. When a chute is activated by flight crew in an emergency, a small explosive blast of air travels through a hose and into the regulator before forcing the air into a chamber called the aspirator, which has several small orifices that create a 'venturi effect' (low-pressure system). The resultant behavior aspirates (sucks in) air into the evacuation chutes causing instant inflation. When activated, the regulators have a piston that compresses the Bellevilles thus regulating the pressure.



Aircraft emergency evacuation safety instructions via Getty Images

For additional information, please contact Solon Manufacturing Co.  
800.323.9717 | [sales@solonmfg.com](mailto:sales@solonmfg.com) | [www.solonmfg.com](http://www.solonmfg.com)



## JAPAN AIRLINES RUNWAY COLLISION & EVACUATION

The manufacturing and inspection processes are tightly controlled, and the design must adhere to stringent testing criteria, such as precision load and friction requirements. A recent example of the application at work was showcased on January 2, 2024, when an Airbus A350 Japan Airlines aircraft collided with a Japanese Coast Guard plane shortly after touching down on the runway. Unfortunately, five of the Coast Guard members were killed, and the pilot was seriously injured. However, 379 passengers and crew members of flight JAL516 survived, evacuating by swiftly and safely sliding down the emergency evacuation chutes containing the NMG Aerospace inflation equipment. Details from this incident have confirmed that the flight crew was able to evacuate all passengers from the burning plane in just under 18 minutes, using three escape chutes out of the plane's eight available exit doors.



*Japan Airlines runway crash and emergency evacuation on January 2, 2024 via Associated Press*

## ‘MIRACLE OF THE HUDSON’ LANDING & EVACUATION

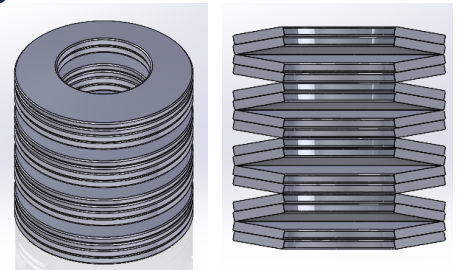
Another famous example of the successful deployment of emergency evacuation equipment on an aircraft occurred on January 15, 2009, when US Airways Flight 1549 struck a flock of birds shortly after takeoff from LaGuardia Airport, losing all engine power. With no time to turn back toward LaGuardia, or attempt a landing at a nearby New Jersey runway, Pilots Chelsey “Sully” Sullenberger and first officer, Jeffrey Skiles, made the calculated decision to glide the plane to ditching on the Hudson River off Midtown Manhattan. Once the order was given to evacuate, the crew began evacuating all 155 passengers through the four wing-window exits where the emergency evacuation slides were deployed. As frigid water began entering the aircraft through holes in the fuselage and cargo doors, evacuees moved to stand on the wings of the aircraft or waited on the partially submerged slides to be rescued by the NY Waterway ferries, the U.S. Coast Guard, and other numerous boats in the water that day. Miraculously, everyone survived with only a few serious injuries.



*‘Miracle on the Hudson’ US Airways emergency landing on the Hudson River on January 15, 2009 via Associated Press*

## SOLON SOLUTION: STACKING ARRANGEMENTS

In addition to installing [Solon Belleville Springs & Washers](#) to the fastening system for bolted connections, using them in a [stacking arrangement](#) as structural or control components for machines ensures a proven and reliable solution for applications subjected to fatigue issues, friction, high loads, displacement, and elevated or cryogenic temperatures- that are critical to the successful operation of the equipment.



*Solon Belleville Spring Washers in a stacked configuration*

[Solon Manufacturing Company](#), an industry leader on engineered solutions for critical applications, can help from design through aftermarket to ensure bolts have the correct mating parts that will effectively support design requirements. Often there are standard options already available, though a custom Belleville washer can be engineered around specifications.

Additional information such as calculator tools, videos, case studies and technical white papers can be found in our [resource library](#).



For additional information, please contact Solon Manufacturing Co.  
800.323.9717 | [sales@solonmfg.com](mailto:sales@solonmfg.com) | [www.solonmfg.com](http://www.solonmfg.com)