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Rated for 20 G

Rotary Switchgear Proven for Shock, Vibration & Mission Survivability

TECHNICAL WHITE PAPER

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Built to protect. Engineered to perform.

Abstract

Shock is a physical event, not a theory. Naval vessels, submarines, armoured vehicles and mobile defence systems all experience instantaneous acceleration forces that can reach 20 G. When that happens, electrical continuity must survive the impact.

This whitepaper explains how Santon rotary switchgear maintains full functional performance after experiencing 20 G mechanical shock, based on independent testing performed at TNO Delft. It also references supporting DC endurance validation to demonstrate stable operation before and after mechanical events.

The goal is simple. Clarify what true shock-resistant switchgear is, and why it matters when electrical power cannot be allowed to fail.

0. Preface – Purpose of This Document

This document has been developed to give engineers, designers and technical buyers a clear understanding of what defines shock-resistant rotary switchgear. Not through marketing claims, but through independently verified testing and engineering fundamentals.

Behind every digital system lies a physical truth: power must still be manually controllable.

It explains the forces involved in a 20 G event, how Santon designs survive them and why these design decisions matter to the operational reliability of naval, defence, transport and mission-critical industrial systems.

Its purpose is educational. To clarify the engineering principles behind mechanical survivability so readers can differentiate between light-duty rotary devices and switchgear intended for the most severe environments.

1. Introduction – Why Shock Matters

Modern systems rely on electrical continuity. Yet every physical platform, from submarines to armoured vehicles, experiences impact, vibration, structural coupling or shock.

A 20 G event can deform housings, misalign shafts, distort rotor geometry and interrupt the very function that keeps a system alive.

Digital controls recover. Software resets. But when the structure moves, only mechanical systems provide certainty.

A rotary switch remains the final physical safeguard when everything else is under stress. That is why shock survivability is not optional. It is essential.

A rotary switch is not an alternative to electronics. It is the foundation that makes electronics safe.

2. Validation Heritage – Four Decades of Independent Shock Testing

Before discussing how Santon achieves 20 G survivability today, it is important to recognise that this capability did not appear suddenly. It is the result of four decades of independent validation across naval, submarine and defence platforms.

German Navy BV043 / BV044 qualification
Earlier generations of Santon switchgear underwent extensive shock programmes under German Navy BV043 and BV044. These programmes established the engineering

foundation that Santon continues to build on today. They demonstrated survival under naval-grade shock loading and stable performance after impact.

Upholder-class submarine programme (UK MOD)
Santon rotary switches were also supplied into the UK Ministry of Defence Upholder-class submarine programme. Shock survivability and electrical integrity were mandatory. The engineering knowledge gained here remains part of Santon's design DNA.

Historical high-G testing
Previous product generations were validated at shock levels far above 20 G, in some cases up to 200 G for submarine applications. These values are historical and not performance claims for current products. They show that Santon has engineered for extreme shock environments for decades.

Standards lineage
Across this history Santon engaged with:

- MIL-STD-901D
- NATO STANAG 4370
- German Navy BV043 / BV044
- UK submarine shock requirements

This heritage does not change today's 20 G rating. It explains why Santon's shock engineering is grounded in real, repeatable practice.

3. What a Rotary Switch Must Do Under Shock

When a platform takes a hit, nothing moves slowly. The structure jumps. The mass shifts. Components fight to stay where physics no longer wants them to be. In that moment, a rotary switch has one job. Stay predictable.

It must hold the circuit open or closed with the same confidence it had before the impact. That sounds simple. It is not. A shock event tests every weakness at once. Bearings want to walk out of alignment. Shafts want to twist ahead or lag behind. Contacts want to unload or bounce. Frames want to flex.

A rotary switch that survives shock must do several things at the same time:

- keep the circuit isolated when needed
- maintain stable contact pressure
- prevent contact bounce
- preserve shaft alignment
- transfer energy safely through the mechanism
- provide consistent torque feedback
- prevent deformation across every pole

Shock exposes the truth of the design. It shows whether the mechanism was engineered or assembled. It leaves no room for luck.

To survive 20 G, the switch must behave as if nothing happened. The environment can move violently. The mechanism cannot. This is where mechanical certainty matters.

4. Understanding the Forces of a 20 G Event

A 20 G shock arrives in a single pulse. The structure moves before the mechanism can react. The switch must keep its geometry while the mounting surface shifts beneath it.

A 20 G half-sine pulse lasting 25 milliseconds equals:

- about 200 m/s^2 acceleration
- about 40 to 45 mm displacement at peak response
- roughly 380 joules of impact energy per kilogram of mass

These values matter. They explain what the switch must survive.

During a shock event:

- bearings push against their seats
- shafts try to rotate ahead or fall behind
- contact systems feel a drop in force
- frames flex if the structure allows it
- alignment is challenged across all interfaces

A light-duty switch may lose pressure or bounce the moment the housing shifts. A mechanism built for survivability keeps its internal forces under control.

Low inertia prevents the rotor from accelerating on its own. Balanced geometry reduces amplification. Correct bearing preload stops deflection. Spring systems keep contact force stable, even when acceleration reverses.

A shock pulse lasts only milliseconds, but it exposes everything inside the mechanism. If the design has weaknesses, they appear at that exact moment. The structure moves. The shock ends. The switch must still function.

5. Santon's Engineering Approach to Shock Survivability

A rotary switch does not survive 20 G by being strong in one place. It survives because each part behaves predictably when the structure moves. Engineering starts long before testing. It begins with controlling mass, stiffness and force.

Mass symmetry and low inertia
A rotor with uneven mass amplifies motion. Even a small imbalance grows during shock. Symmetric rotors with low inertia prevent self-acceleration when the platform moves.

Reinforced bearing architecture
Shock loads drive bearings into their seats. If they shift, the shaft loses alignment. High-strength bearing supports keep the shaft centred and torque feedback stable.

Rigid mechanical anchoring
Frames take the first hit. Their task is to keep every part in position. A rigid anchor keeps the mechanism aligned during the pulse.

Positive-acting mechanisms
Acceleration reverses direction within milliseconds. Contacts must hold pressure through that reversal. Spring-loaded systems maintain force and prevent bounce.

Independent pole construction
Each pole is its own switching chamber. If stress reaches one area, it does not propagate to the others.

Encapsulated switching zones
Contamination can shift under vibration or shock. Encapsulation protects contact geometry from debris.

Finite-element analysis guidance
FEA shows where stress accumulates. It guides decisions on rotor geometry, bearing support and frame stiffness. The result is a mechanism that behaves the same way every time, even when the shock is unpredictable.

These features work together. None of them are optional.

6. Independent Shock Testing at TNO Delft

Shock performance becomes meaningful only when verified independently. Santon uses the Structural Dynamics Laboratory at TNO Delft, a facility recognised across NATO programmes and used for naval qualification.

Test approach

- Acceleration: 20 G
- Pulse shape: half-sine
- Duration: 25 ms
- Orientation: three perpendicular axes
- Reference: MIL-STD-901D

This checks the mechanism from all sides, not only the most favourable axis.

Results

- no mechanical deformation
- no shaft or bearing displacement
- no loss of contact force
- no unintended closures
- no bounce
- no functional degradation
- full switching performance after each pulse

This establishes 20 G as the mechanical survivability baseline.

7. Supporting Electrical Performance (Before and After Shock)

Shock resistance has no value if the switch cannot function electrically afterward. Mechanical stability must translate into stable electrical behaviour.

Independent tests at Prof. Ir. Damstra Laboratory and DEKRA Arnhem measured DC load performance, temperature variation and operational endurance before and after shock.

Validation scope

- 250 V DC / 63 A (DC-22B)
- temperature range −20 °C to +85 °C
- 300 loaded switching operations
- 1700 off-load operations
- dielectric withstand at 1415 V DC
- contact resistance trend analysis

Results

- no welding or sticking
- no thermal instability
- stable contact resistance
- unchanged dielectric strength
- repeatable switching behaviour

The switch keeps its alignment and contact force, which protects the electrical function. It does not only survive impact. It continues to operate.

8. Why 20 G Matters Across Real Platforms

Shock events appear across defence and mission-critical environments. The details vary. The effect is the same. The structure moves faster than the mechanism can react. A switch built for survivability continues to function.

Naval and submarine environments
Structures transmit energy from underwater events, heavy weather or internal loads. A switch that loses contact could interrupt propulsion, sensors or auxiliaries.

Armoured vehicles
Terrain impacts and recoil create high, short-duration loads. A shock-validated switch prevents unintended power loss.

Mobile defence systems
Radar trailers and generator units face movement, handling and EMI. Electronic controls may reset. A mechanical isolator stays where it is set.

Industrial and mission-critical environments
Unexpected loads can occur during shutdowns or equipment failure. Isolation must remain certain. A 20 G-validated switch keeps its geometry so lock-off procedures stay reliable.

Across all cases, the principle is the same. When the structure moves, the switch must not.

9. Conclusion

Shock resistance determines whether rotary switchgear can be trusted when the platform experiences sudden acceleration. A 20 G event challenges bearings, shafts, frames and contacts at the same time. A switch that survives does so because its design controls mass, geometry and force with precision.

The TNO programme confirmed that the mechanism remains intact, aligned and fully functional after each shock pulse. The electrical validation shows that contact behaviour, dielectric strength and thermal stability remain stable before and after the event.

A rotary switch validated for 20 G provides certainty. It supports reliable isolation, safe distribution and predictable operation in demanding environments.

Rated for 20 G.

Tested for survivability.

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Engineered to perform.

Footnote
For engineers evaluating water ingress and environmental sealing (IP ratings), see Santon Technical White Paper 2025-03: "Water Ingress Protection & Environmental Sealing of Rotary Switchgear."

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