

Declaration of Conformity (CUBEX_080420)

Marcus Punch Pty. Ltd. was engaged by Nautitech Mining Systems Pty. Ltd. to perform a hardware safety integrity verification on their “CUBEx” Intrinsically Safe (IS) Engine Safety Shut-down System against the requirements of AS61508.2-2011¹. The verification was conducted according to the ‘probabilistic / deterministic’ route (Route 1).

The details of the analyses and reviews that lead to these findings are provided in our report:

NAU-18-01-B Rev.3, CUBEx Intrinsically Safe (IS) Engine Safety Shut-down System – SIL Calculation Report (dated 8th April 2020).

Safety Function	Probability of Failure on Demand (PFD)²	Probability of Dangerous Failure Per Hour (PFH)	Architectural SIL Claim Limit (SILCL)	Overall SILCL (Low Demand)	Overall SILCL (High Demand)
SF#1: CX050 Engine Speed - Engine Shut-down	4.6x10 ⁻³	9.4x10 ⁻⁷	SIL2	SIL2	SIL2
SF#2: CX051 Coolant / Exhaust Temperature - Engine Shut-down	4.4x10 ⁻³	9.1x10 ⁻⁷	SIL2	SIL2	SIL2
SF#3: CX052/070 Engine Oil / Strangler / Fuel Pressure - Engine Shut-down	4.4x10 ⁻³	9.1x10 ⁻⁷	SIL2	SIL2	SIL2
SF#4a: CX053 Gas (Methane) - Engine Shut-down (Single sensor)	5.8x10 ⁻³	1.2x10 ⁻⁶	SIL2	SIL2	SIL1
SF#4b: CX053 Gas (Methane) - Engine Shut-down (Dual sensors)	4.6x10 ⁻³	9.6x10 ⁻⁷	SIL2	SIL2	SIL2
SF#5a: CX055/058/086 (ZMT32) Position - Engine Shut-down	4.4x10 ⁻³	9.1x10 ⁻⁷	SIL2	SIL2	SIL2
SF#5b: CX055/058/086 (MLX90316) Position - Engine Shut-down	4.4x10 ⁻³	9.1x10 ⁻⁷	SIL2	SIL2	SIL2
SF#6a: CX075 CLS Level - Engine Shut-down (dual IOMs)	2.6x10 ⁻³	5.4x10 ⁻⁷	SIL2	SIL2	SIL2
SF#6b: CX075 CLS Level - Engine Shut-down (single IOM)	4.4x10 ⁻³	9.1x10 ⁻⁷	SIL2	SIL2	SIL2
SF#7a: CX080 LTS Level - Engine Shut-down	4.5x10 ⁻³	9.2x10 ⁻⁷	SIL2	SIL2	SIL2
SF#7b: CX080 LTS Temperature - Engine Shut-down	4.5x10 ⁻³	9.2x10 ⁻⁷	SIL2	SIL2	SIL2

¹ With the exception of SF#9. This SF has been evaluated against the requirements of ISO13849 (via a Performance Level or PL) as it is comprised of “other technology” (eg. mechanical) safety-related parts.

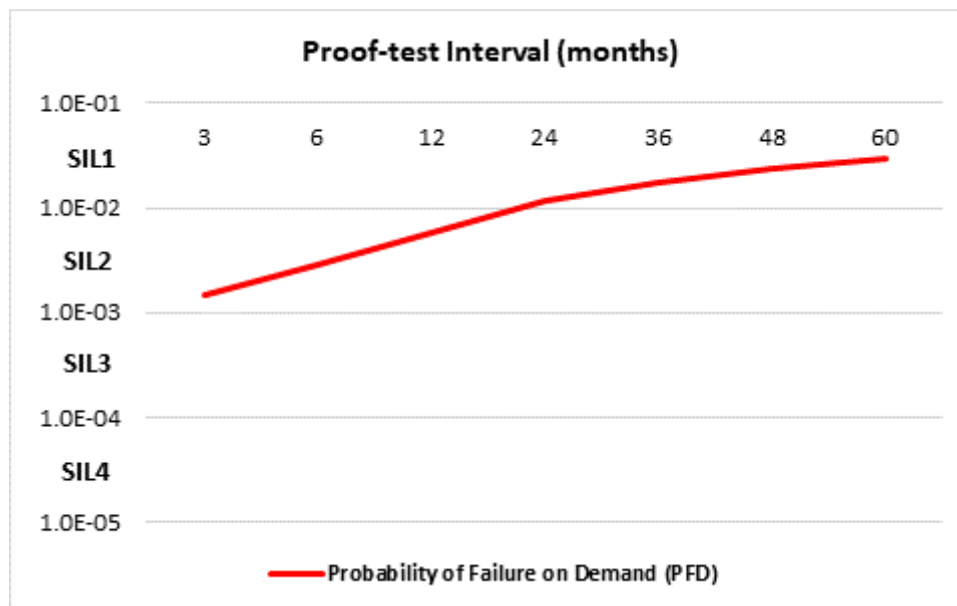
² A proof-test interval of one (1) year is assumed for these PFD values.

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Risk and Reliability

Safety Function	Probability of Failure on Demand (PFD)	Probability of Dangerous Failure Per Hour (PFH)	Architectural SIL Claim Limit (SILCL)	Overall SILCL (Low Demand)	Overall SILCL (High Demand)
SF#8a: CX087 MLS Level - Engine Shut-down	4.4×10^{-3}	9.0×10^{-7}	SIL2	SIL2	SIL2
SF#8b: CX087 MLS Temperature - Engine Shut-down	4.5×10^{-3}	9.2×10^{-7}	SIL2	SIL2	SIL2
SF#9: Manual Engine Shut-down (with CUBex) ³	Evaluated as capable of ISO13849 PLd with PFH= 2.3×10^{-7} and PFD= 1.0×10^{-3} .				
SF#9: Manual Engine Shut-down (without CUBex) ⁴	Evaluated as capable of ISO13849 PLc with PFH= 1.1×10^{-6} and PFD= 4.8×10^{-3} .				

A PFD curve for various proof-test intervals is provided below for the electrical / electronic / programmable electronic safety functions. This curve represents SF#4a (CX053 Gas (Methane) - Engine Shut-down (single sensor)), which has the highest dangerous failure rate of all of safety functions, and thus represents the worst-case.



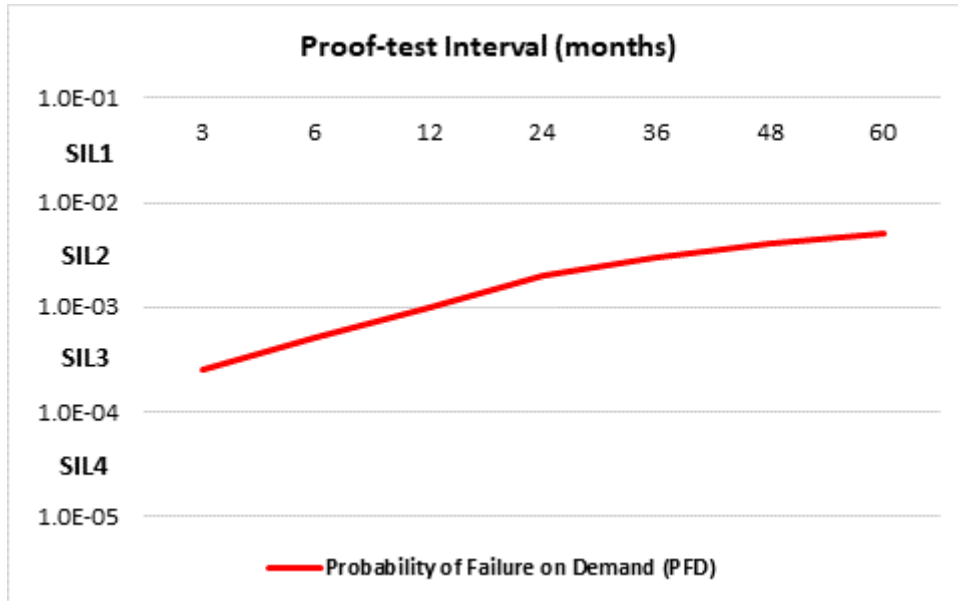
³ The CUBEx can detect if the Manual Shut-down has been demanded via the strangler pressure sensor. If the engine does not stop after the pushbutton is operated, the CUBEx system performs a back-up shut-down via the solenoid piezo valves.

⁴ In the event that the CUBEx system is not correctly operating at the time of a Manual Shut-down demand (ie. because the CUBEx system has failed to shut-down the engine and the Manual Shut-down is being used as a back-up measure), the fault detection provided by the CUBEx system cannot be relied upon. An additional SIL/PL evaluation has been carried out for this case.

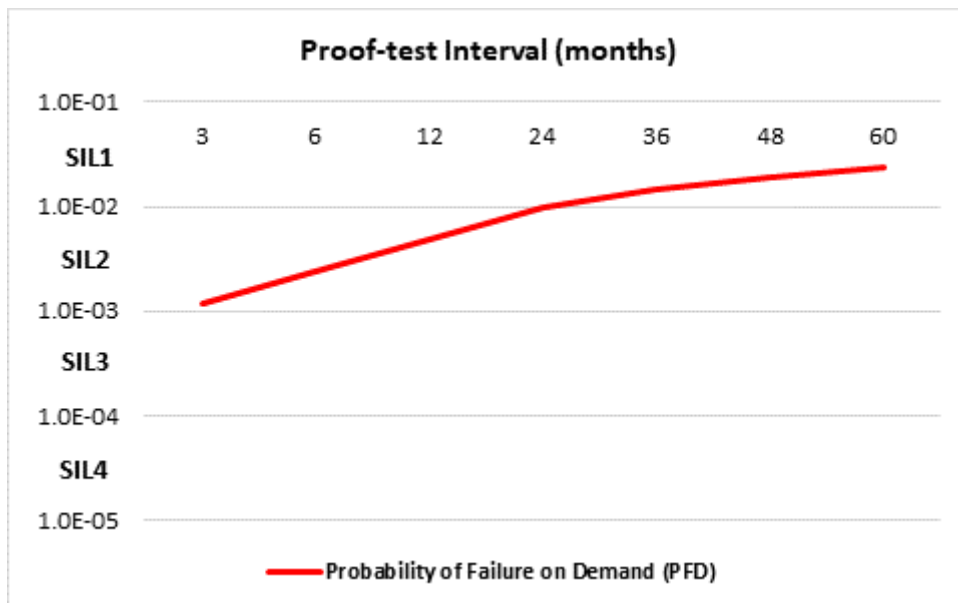
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Risk and Reliability

A PFD curve for SF#9, with consideration of the back-up shut-down provided by the CUBEx system, is provided below:



A PFD curve for SF#9, without consideration of the back-up shut-down provided by the CUBEx system, is provided below:



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