Risk analysis for Hangprinter with FDM extruder

risk	possible damage (1-10) 1 = minimum, 10 = maximum	probability of occurrence (category) 1 = low 2 = medium 3 = high	rating= scope of damage x probability of occurrence	counteraction(s) and hints

line construction • lines break / loosen • guests / guides get tangled → risk of injury (stumbling, pinching off; possibly burning at the hot end • construction is badly damaged	10	3	30	• suitable shut-off of the device operation / entering the construction only by trained personnel • check deflection pulleys, check parts for sharp edges or generally mechanical contact points for abrasion • check lines knots → do not use simple knots; use special knots • use of tear-resistant lines (special fishing line with sufficient traction and diameter) • occasional inspection / maintenance

parts of the machine fall off • e.g. screws or plastic parts • visitors could get hurt • machine could be damaged (malfunction)	8	2	16	• secure screws with screw locks or use stop nuts • check the connection stability in an acceptance report • occasional inspection / maintenance (protocol) • produce parts from elastic material (tendency to brittle fracture / prevent cracks) → use a high degree of infill

hotend or extruder smokes or burns • device destruction • smoke detectors and sprinkler systems damage the exhibition • filament / substrate is set on fire	10	1	10	• redundant thermal sensor • recent firmware with temperature jump measurement, watchdog and automatic emergency shutdown • safe installation of the sensors (gluing / screwing) • regular inspection / maintenance (protocol) • **consequences when entering are destructive**

controller parts smokes or burns • device destruction • smoke detectors and sprinkler systems damage the exhibition	10	1	10	• electrical inspection / acceptance with detailed protocol • buy high quality electronics • use high quality wiring / cabling and shielding (generous cross-sections, good manufacturers) • **consequences when entering are destructive**
Software • print does not start • print result does not match the input	3	3	9	• extensive testing and logging / documentation • establish remote maintenance routines

collisions between printed part and lines • design-related variability of the possible pressure dimensions depending on height Z • The machine could tangle and damage itself	8	1	8	• simulation of the model to be printed with the appropriate software

errors in print part - vibrations during printing • by heavy trucks driving next to the building • by wobbling on the frame by guests / visitors	3	2	6	• store the machine on a tight (spring) frame • situate warning panels with information like "Do not touch.", Print may loose traction." or similar • select the line diameter so that the installation becomes stable against stretching

material loss - tool oozes • material spills uncontrol lably on the printing platform or at other points in the effective radius of the machine • due to insufficie nt screwing between the hot end heating block and the nozzle (thermal transition zone)	3	2	6	• check for tightness of the strand compone nts and note them in the acceptan ce report • regular inspectio n / maintena nce (protocol) • no further counter measure s possible (cannot be checked - only optically)

material does not stick → " spaghetti salad" • at the start of printing • during printing • leads to wasted material	3	2	6	• regular cleaning of the printing surface • check the distance between the platform and nozzle • check the overhang angle in the print model and calculated support structures • checking the printing parameters (layer height, extruded volume per unit of time, etc.) • establish stability in the printing frame (no accidental offsets by warping the machine frame → thus offset in the printing part)

material extrusion fails • extruder problem (clogging) / mechanical defect / heating failure • material feeder blocked • material torn	2	2	4	• kink protection for filament (filament guide → PTFE) • check for blockages in the hotend

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