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| 2019 Robot and Inspection Rules Summary |
| 10.1 | Overview |
| COMPONENT: part in most basic configuration |
| MECHANISM: assembly of COMPONENTS with specific function |
| COTS: standard (non custom order) item available to all teams, unmodified, obsolete OK |
| VENDOR: Tax ID; not a FIRST team; ship COTS ≤5 days; maintains stock; products available to all teams;  |
| FABRICATED ITEM: COMPONENT or MECHANISM altered…\* |
| 10.2 | General Robot Design |
| R1 | FRAME PERIMETER: in bumper zone; fixed non-articulated structural; excl minor prot. ≤ ¼" |
| R2 | STARTING CONFIGURATION ≤ FRAME PERIMETER (excludes bumpers & minor protrusions) |
| R3 | FP ≤ 120 inches, Starting height ≤ 48" |
| R4 | Max extension: 30" beyond FP |
| R5 | Robot weight ≤ 125 lb (excl bumpers, battery w/ <12" cable) |
| 10.3 | Safety & Damage Prevention |
| R6 | not designed to shoot H PANEL > 3' past FP (G6) |
| R7 | "71 rule": limits damaging traction devices \* |
| R8 | No hazards from protrusions or exposed surfaces |
| R9 | General hazmat, safety & interference rule \* |
| R10 | No power to remove game pieces or robot |
| R11 | Lubricants: internal only |
| 10.4 | Budget Constraints and Fabrication Schedule |
| R12 | BOM ≤ $5500, excludes ≤$5/part & 2019 KoP |
| R13 | Individual part ≤ $500 |
| R14 | BOM uses Fair Market Value: COTS is VENDOR price; else materials & non-team labor costs |
| R15 | No physical elements before kickoff. Exceptions: operator console; bumpers; battery assemblies; single COTS electrical + wires modified, connectors, shaft, gear, pulley, filter capacitor |
| R16 | software/designs before kickoff must be public |
| R17 | Bag ROBOT by Feb 19 2259 CST, excludes withholding, bumpers, COTS |
| R18 | up to 3 bags, separate tags & entries, one form |
| R19 | Re-seal if attending another event |
| R20 | Hands-off times and exceptions & limitations \* |
| R21 | Robot access times for 2 day events \* |
| R22 | Unbag at competition only after lock-up form approval and pits open |
| R23 | WITHHOLDING ALLOWANCE ≤ 30 lb \* |
| 10.5 | Bumper Rules |
| R24 | Cover corners to 6 in; curves are corners |
| R25 | In BUMPER ZONE (0-7.5") except per G23 (HAB)\* |
| R26 | BUMPERS non-articulated rel to FP |
| R27 | Quick/easy installation & removal for inspection |
| R28 | Red/Blue; no markings except: R29, hook & loop or snaps on hard parts, white FIRST logo |
| R29 | numbers: visible all sides; Arabic num 4+" tall; ½"+stroke; white or w. outline; not around sharp corners; no subst. logos or icons for numerals |
| R30 | Bumper set, incl fasteners & structures ≤ 15 lb |
| R31 | Bumpers must be constructed as follows: |
| a |  ¾" nom x 4.5-5.5" plywood or robust wood |
| b | no hard parts >1" beyond FP |
| c | pair of 2.5" (nominal) round, petal, hex pool noodles, solid or cored. No mods or deforms except end cuts; All same in a bumper set; soft fasteners inside OK, but mind cross-section |
| d | Rugged smooth solid color cloth on ext. surfaces\* |
| e,f | metal angle/bracket may secure cloth & segments |
| g | attach rigidly to FP \* |
| R32 | Fill the cornerjoints with pool noodle |
| R33 | FP backing: ½" @ ends; gaps ≤ ¼" deep, ≤8" wide |
| 10.6 | Motors & Actuators |
| R34 | Only motors permitted (any quantity) |
|   | List of Motors \* (overview in R37 rows 1 to 3) |
|   | solenoid, ≤1" stroke, ≤10W cont at 12V. |
|   | hard drive motors or fans in kickoff/FIRST Choice; or part of controller or COTS computing |
|   | vibration & focus motors in COTS computing |
|   | PWM COTS servos with a retail cost < $75 |
|   | Motors integral to COTS sensor |
|   | One R86 compliant compressor to compress air |
| R35 | No motor mods except |
|   | Mounting brackets & output shaft |
|   | Leads trimmed, connected, or spliced |
|   | remove Denso motor window locking pins |
|   | conn. housings on KOP auto for connections |
|   | Servos as specified by the manufacturer |
|   | Dynamo wiring harness as doc'd by FIRST\* |
| R36 | Except servos, fans & integral motors, each actuator must be controlled by one of: |
|   | MC (Motor Controllers): DMC 60[c]; Jaguar (PWM); Dynamo integrated; SD540; Spark; Spark MAX; Talon; Talon SRX; Victor 884, 888, SP, or SPX.\* |
|   | RM (Relay Modules): Spike; Automation Direct\* |
|   | PC (Pneumatics controllers): PCM |
| R37 | Power regulator to load map. UNO, 1 load/reg |
|   | 1/MC: CIM; AM 9015 RS775 Pro BAG; mini-CIM; Banebots; AM RedLine; NEO |
|   | 1/MC or 1/RM: KOP Auto; AM PG; Snow Blower; NeverRest |
|   | Integrated controller only: Nidec Dynamo |
|   | RM or PC: Compressor |
|   | multi/RM or 1/PC: pneumatic solenoid valves |
|   | multi/MC or RM, or 1/PC: solenoids or CC |
|   | CC (CUSTOM CIRCUIT): electrical COMPONENT except motor, pn. solenoid, roboRIO, PDP, PCM, VRM, RSL, 120A breaker, MC, RM, radio, battery |
| R38 | Servos connect to ONE of: RIO PWM, Spartan Sensor PWM, or REV Servo module  |
| 10.7 | Power Distribution |
|   | Apply for event, not just FIELD/MATCHES |
| R39 | Battery is robot's only electrical energy source: Non-spill SLA, 12V, 17-18.2Ah, rectangular 7.1"x3"x6.6"; 11-14.5#; nut/bolt terminals |
| R40 | COTS computing & I/O may be powered by integral or 100Wh USB batteries 2.5A max/port. Musts: secured, COTS cables, mfg recc charging |
| R41 | Battery chargers need installed SB connector |
| R42 | Battery chargers only used at ≤ 6A charging |
| R43 | R39 & R40 only batteries on robot, period |
| R44 | Secure the battery, including rolls & inversions |
| R45 | All mains connections fully insulated at all times |
| R46 | Only non-elec energy: compressed air per R86 & R87; change robot CoG; deformation (springs); closed-loop gas shocks; air filled wheels |
| R47 | Mains circuit: 1 battery, 1pr SB conn., 1 120A breaker\*, 1 PDP, connected with 6+ AWG copper wire only, no add'l devices or mods, per fig 10-9 |
| R48 | Circuits powered from ONE PDP WAGO pair (except R53 & R55) |
| R49 | Isolate electricals from ROBOT frame (>3kΩ) |
| R50 | ONE main breaker, quickly & safely accessible |
| R51 | PDP, wiring, breakers: easily visible (inspection) |
| R52 | CC may not produce voltages > 24V |
| R53 | RIO power ONLY from designated PDP terminals |
| R54 | Radio power ONLY from 12V 2A VRM output |
| R55 | Radio's VRM powered by designated PDP terminals. 1 PCM is only other load there |
| R56 | PDP: One WAGO, one wire. |
| R57 | Only PDP breakers are Snap Action: VB3-A series F57 terminals; MX5-A or MX5-L series, ≤40A |
| R58 | Fuses in PDP: mini-automotive rated as marked. |
| R59 | One breaker one circuit. Breaker values: |
|   | ≤40A: (MC | CC | 40A AD relay), 1ea |
|   | ≤20A: Fans, no limit; (Spike | 25A AD relay), 1 ea |
|   | ≤ 10A: 12A AD Relay, 1 ea |
|   | 20A: PCM w/compressor, 1 ea; VRM and/or PCM without compressor, 3 total |
| R60 | All circuits: insulated copper wire sized at least:  |
|   | 12 AWG: 31-40A protected circuit |
|   | 14 AWG: 21-30A protected circuit |
|   | 18 AWG: 6-20A; PDP->(VRM, PCM->compressor) |
|   | 22 AWG: ≤5A; PDP->RIO |
|   | 24 AWG: VRM 2A circuits |
|   | 26 AWG: RIO PWM port putputs |
|   | 28 AWG: SIGNAL LEVEL (≤1A draw and source) [Examples\*] May be non-copper. |
|   | Exempt: wires recommended/attached by mfg |
| R61 | Connectors, slip rings, etc.: protected as rated |
| R62 | Non-signal level, constant polarity wiring shall be color coded the entire length as follows: |
|   | Pos: red, yellow, white, brown, black w/stripe |
|   | Neg: black, blue |
|   | Exempt: orig attached to devices, POE ethernet |
| R63 | Custom circuits may not directly alter power\* |
| 10.8 | Control, Command, & Signals System |
| R64 | One RoboRIO, image version ≤ FRC\_2019\_v12 |
| R65 | One OM5P-AN or OM5P-AC radio, cfg for event |
| R66 | RIO ethernet => "18-24vPOE" port on radio. Network switch allowed but discouraged. |
| R67 | Robot-> console comms is limited to 4Mb/s and to specific network ports\* |
| R68 | Configure RIO, DS, & radio as directed\* |
| R69 | All signals must be Console -> Arena -> ROBOT |
| R70 | No wireless to/from robot except per R65 & R69 |
| R71 | Mount radio so diagnositc lights are visible |
| R72 | 1 or 2 RSLs, visible 3' away, RIO RSL+ terminal to both La and Lb, RIO RSL- terminal to RSL center |
| R73 | No mods to DS SW, RIO, PDP, PCM, VRM, RSL, breaker, MCs, RMs, radio, or batteries except: |
|   | User programmable code on RIO |
|   | Calibration of motor controllers per manuals |
|   | Fans on motor controllers from their power |
|   | Spike relay ==> compressor may have breaker |
|   | Wires, cables, signal connected as provided |
|   | Fasteners, including adhesives OK |
|   | Thermal interface material/paste ok |
|   | Labels ok |
|   | Jumpers may be moved. |
|   | Jaguars: custom limit switch circuit OK |
|   | Mfg supplied firmware updates OK |
|   | Wires on MCs cut, stripped, connectorized |
|   | Devices repaired (not improved) |
|   | Talon SRX data port cover removed |
|   | Tape may be applied to Al plate inside radio |
| R74 | Except designated 12V input, no 12V power, RM, or MC outputs shall be connected to the RIO |
| R75 | Every power controller connected properly\* |
| R76 | Motors controlled via MXP must be controlled via PWM pins, passive condictors to extend same, or an approved ACTIVE DEVICE: : Kauai Labs navX MXP; RCAL MXP daughterboard; REV RIOduiono; REV Digit Board; WCP Spartan Sensor Board; Huskie 2.0 board. |
| R77 | Each CAN MC must be controlled from the RIO, passed via PWM (per R75) or CAN, but not both. |
| R78 | Each PCM controlled from the RIO via CAN. |
| R79 | The PDP CAN must be connected to the RIO |
| R80 | CAN may have extra non-interfering devices |
| 10.9 | Pneumatic System |
|   | Apply for event, not just FIELD/MATCHES |
| R81 | Pneumatic parts: forbidden unless permitted |
| R82 | Pneumatic items: COTS and (rated for 125 psi, or downstream of regulator & rated for 70psi) |
| R83 | original, unaltered except: cut tubing; wiring modified for interface; assembly using pre-existing threads/brackets/fittings; removing mounting pin (but not cylinder); labeling. |
| R84 | The only pneumatic items permitted:  |
| a | KoP-equi vent plug valves |
| b | KoP-equiv pressure relief valves;  |
| c | Solenoid valves ⅛" (3mm) NPT, BSPP,BSPT diameter, or ¼" OD tubing connectors |
| d | pneumatic tubing, 1/4" max OD |
| e | transducers, gauges, flow control valves, manifolds, and connection fittings |
| f | check & quick exhaust valves meeting R93a |
| g | Releiving shutoff valves (3-way exhausting) |
| h | regulators adjusted to 60 psi or less |
| i | cylinders, linear and rotary actuators |
| j | storage tanks, except white clippard tanks |
| k | One compressor, R86 compliant |
| l | Debris or coalescing (water) filters, |
| m | Venturi valves (high pressure is subject to pneumaticrules, vacuum side is exempt) |
| R85 | If pneumatic used, following are required: |
|   | One (1) FRC-legal compressor (per R86) |
|   | Relief valve (R84-b) via rigid fittings to compressor |
|   | Nason pressure switch SM-2B-115/R443 |
|   | at least on pressure vent plug |
|   | Stored pressure gauge, upstream of primary reg |
|   | Working pressure gauge, downstream of regulator |
|   | Working pressure regulator |
|   | IMAGE \* |
| R86 | ONE onboard compressor, 1.1 cfm. |
| R87 | Stored air ≤ 120 psi. None stored offboard. |
| R88 | One primary adj. releiving regulator ≤ 60 psi. |
| R89 | Only compressor, relief, p. switch, vent plug, gauge, tanks, tubing, p. transducer, filters, fittings on high pressure side |
| R90 | Gauges easily visible on high and low sides |
| R91 | Relief valve: hard fittings to compressor output |
| R92 | Nason p. switch SM-2B-115/R443; high side, wired to PCM or to RIO programmed for shutoff |
| R93 | Vent plug: vent all air pressure & be accessible |
| R94 | Don't plumb solenoid valve outputs together |
| 10.10 | Operator Console |
| R95 | NI Driver Station rev 19.0 or newer |
| R96 | must include diagnostic graphic display visible for inspection and match |
| R97 | Driver station: direct connect to FMS (no switch) using proded cable. Ethernet port accessible. |
| R98 | ≤ 60" long, ≤14" deep or worn/held, ≤78" from floor, no attachment except loop tape & ethernet |
| R99 | No wireless comms except FMS |
| R100 | No hazmat, unsafe conditions, or interference |
| 11 | Inspection & Eligibility Rules |
|   | LRI final authority |
|   | May practice uninsp. FTA may pull if unsafe |
|   | BYPASS/DISBLE by FTA, LRI or Head Ref\* |
| I1 | Built by team to play DDS\* |
| I2 | Get inspected before playing a qual match |
| I3 | Present all mechanisms, configurations, and decorations at inspection. Subsets OK\* |
| I4 | Reinspect for any change except: fasteners, labeling, code, identical COTS or MECHANISM replacement, subsetting  |
| I5 | Present BOM at inspection. R12 for details |
| I6 | Inspect power off, vented, & unsprung except as necessary |
| I7 | student team member for any inspection efforts |