2024-2026 Engine Regulations

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Contents

1 General Introduction

1.1 Definitions:

1.1.1 **ECU** – The INDYCAR approved and supplied Engine control unit (ECU), which is the primary device responsible for the control, monitoring, and data logging of all Engine induction, fuel and turbo charger control sub-systems.

1.1.2 **Engine** – The internal combustion engine including ancillaries and actuator systems necessary for its proper function.

1.1.3 **Engine Pool** – A group of Engines presented to INDYCAR by the Engine Manufacturers for random allocation to Entrant cars. Engines are still considered part of the Engine Pool once they have been put into cars until they have reached the approved change-out mileage or until they are deemed failed and an unapproved change out has occurred.

1.1.4 **Engine Regulations** – These 2024 Engine Regulations, as amended, modified, supplemented, or restated by INDYCAR from time to time.

1.1.5 **Homologation** – The process by which INDYCAR, in its sole discretion, grants approval of an Engine. Homologated shall mean that the Engine has completed Homologation and has been approved by INDYCAR.

1.1.6 **Homologation Period** - The three-year period beginning in 2024 and through 2026.

1.1.7 **INDYCAR Engine Committee (IEC)** - A consultative group chaired by the INDYCAR Managing Director, Engine Development, consisting of representatives from each Engine Manufacturer, a representative from INDYCAR plus other invited attendees when appropriate.

The purpose of the IEC is to provide guidance and consultation on Engine Regulations, sporting matters related to the INDYCAR Rule Book and the Manufacturer Championship. The IEC is also to provide guidance and consultation on technical matters related to the performance, specification, and durability of the Engines provided to the teams.

1.1.8 **Push to Pass** - or Overtake, is a system built into the ECU software that allows Engine boost pressure and Engine crankshaft speed limits to be deployed / increased to a set level when initiated by a Driver from the designated button on the steering wheel for a set total time, depending on track.

1.1.9 All other capitalized terms not otherwise defined herein shall have the meaning set forth in the then-current INDYCAR Rule Book.

1.2 **"Push to Pass" –**–The total time for Push to Pass is set by INDYCAR and is controlled by the ECU. Further, the increase in boost pressure and Engine crankshaft speed limits will be designated by INDYCAR on a per Event basis through a pre-event bulletin. However, any increase in the limits over and beyond what is stated in the Engine Regulations will not be introduced before consultation with the IEC.

2 General Regulatory Framework

2.1 **Rule Stability –** These rules will be stable for a period of three seasons beginning with 2024 (Reference Homologation Table in Appendix I).

Corrections and modifications with respect to Engine Regulations will be decided by INDYCAR after consultation with the IEC.

From time to time, proposals for changes to the Engine Regulations or Series Rulebook may be proposed by members of the IEC. When making such proposals, the party making said proposal should follow these guidelines:

a) Proposals to update or change the rules must show a clear value in either cost, durability, competitiveness, or operational effectiveness and should be backed up with objective evidence

b) Proposals should benefit all parties where applicable (Engine Manufacturers, INDYCAR, and the teams). Proposals that appear to benefit a sole party will not be considered.

c) Proposals that do not have mutual manufacturer support nor INDYCAR support will not be considered further.

d) Proposals must be provided with sufficient time for debate and implementation by the members of the IEC.

Corrections and modifications with respect to Engine Regulations will be decided by INDYCAR after consultation with the IEC.

2.2 **Review of rules –** The IEC will meet regularly to review and to advise on all regulations pertaining to the Engine.

2.3 **Demonstration of conformity –** Manufacturers must demonstrate conformity to INDYCAR Engine Regulations.

2.4 Anything not expressly permitted by these regulations is prohibited without the written

permission of INDYCAR.

3 Internal Combustion Engine Architecture

3.1 **Constraints –** The Engine will be a four-cycle, four poppet valve per cylinder (two inlet, two exhaust), V6, turbo charged engine subject to the constraints below:

a) Engine Displacement–2.200 liter maximum.

b) Cylinders – Six (6), all of equal capacity and displacement

c) Bank Angle – between 60° and 90°.

d) Cylinder Bore – 95mm diameter maximum, round to +/- 0.13mm

e) Engine length, including all sealed parts and the plenum, measured from mounting face to mounting face – 460mm. No part of the Engine may extend beyond this length without INDYCAR's approval.

f) Crankshaft centerline height – 100mm above bottom of chassis (lowest point of sump)

g) Crankshaft – Single-piece, homogenous part with no additional non-ferrous inserts or bolt-on balance weights

h) Main bearing minimum dimension – 48mm diameter

i) Big end journal minimum dimension – 40mm diameter

j) Connecting rods – Homogenous, no welding or bonding

k) Piston pin – single piece only

l) Valve type – Reciprocating circular poppet, return force via coil spring only

m) Spark plug – One per cylinder

n) Ignition system – Coils driven by the mandated ECU only. (Plasma and laser ignition systems are prohibited.)

o) Coatings – DLC and Plasma Assisted Chemical Vapour Deposition (PACVD)-based coatings are not permitted on crankshafts, rods, camshafts, piston skirts or sleeves.

p) Camshafts – Up to four overhead camshafts permitted (2 per bank)

3.2 **Engine crankshaft rotational speed** – is restricted by the ECU to 12,000 rpm maximum with the exception for when Push-to-Pass is active. When Push-to-Pass is active, the Engine crankshaft rotational speed maximum is limited to 12,200 rpm.

The method of control and restriction of Engine speed is determined by INDYCAR, and

any attempt to achieve an average speed higher than what is permitted when INDYCAR Engine crankshaft speed limitation is active is prohibited.

3.3 **Boost pressure –** The maximum absolute plenum pressure between the turbo compressor exit and the inlet to the Engine combustion chambers is restricted to the values as highlighted in Table A – Boost Pressure Limits by Event Type and Season.

Boost sensors will be monitored, sealed and supplied by INDYCAR, and fitted in 2 locations – see Appendix A. Interfering with or modifying the signal from these sensors as seen by the ECU is prohibited.

The boost pressure will be controlled and restricted by the ECU and the use of up to two (2) exhaust wastegate actuators. The method of control and restriction is determined by INDYCAR and allows for an additional 10mbar of control hysteresis above the Event specific or Push-To-Pass limits specified above. Any attempt to achieve an average boost pressure higher than what is permitted when regulation is active is prohibited.

Table A – Boost Pressure Limits by Event Type and Season

Event Type	Pressure (mbar)
Superspeedway & Nashville	1300
Short Oval	1500
Indianapolis 500 Qualifying	1500
Road Course	1500
Road Course Push to Pass	1650

3.4 **Engine Interface –** Engine installation mounting points, gearbox mounting and fuel pump drive must match the mounting points for the chassis and gearbox given in Appendix B, C and J without modification to allow Entrants to use Engines from any Engine Manufacturer without redesign of interfaces (front and rear end, water and oil radiator connections to the heat exchangers and fuel pump drive).

3.5 **Hydraulic pumps** – Hydraulic pump use is not permitted on the Engine or the Car for the purpose of actuation or control. The fuel system may only use a hydraulic pump for delivering fuel at an increased fuel pressure to the injectors.

3.6 **Pneumatic systems –** Pneumatic pumps, actuator, or control mechanisms are not permitted, with the following exception:

a) Pneumatic waste-gate mechanisms.

3.7 **Valve Timing –** Variable valve timing, phasing and lift are not permitted.

3.8 **Propulsion –** No other means of propulsion are permitted.

3.9 **Camshafts** – May be driven only by chain or gears.

3.10 **Electrical fuel pumps –** Are not permitted.

3.11 **Minimum weight** – When measured according to Table B, the Engine shall weigh at least 112.5kg. Ballast, securely retained to the satisfaction of INDYCAR, may be added to the Engine to achieve minimum weight.

When establishing conformity with regards to weight, an Engine shall include the intake system from the plenum entry manifold(s); ignition coils; Engine sensors and wiring; injectors and fuel rails; alternator, cooling and lubrication pumps; flywheel; any type of sub-frame.

Table B shall be referenced when determining Engine weight, the intention being that the Engine can be weighed in the state of completeness as shipped to Entrants.

3.12 **Engine Seals** – INDYCAR will seal Engines prior to installation into the Car. Engine Manufacturers will provide the locations and necessary drillings on the Engine for the application of INDYCAR seals. Seal must be located such that the following cannot be changed or removed from the Engine without removing an INDYCAR seal:

a) Cylinder-head
b) Gear train
c) Camshafts and valve train related components
d) Crankshaft
e) Pistons
f) Connecting rods

Access windows and covers may remain unsealed as long as part cannot be removed through the cover. However, the parts list above may not be adjusted without prior approval from INDYCAR.

3.13 **Heat Shields** – Heat shields attached to the engine are an open development item as long as they do not improve the aerodynamics of a Car. Any design must be approved by INDYCAR prior to being installed on an Engine in a Team's Car.

3.14 **External Surface –** With the exception of the exhaust outlet pipe (tail pipe), the external surfaces of the engine and all of its ancillaries must remain within the standard Dallara bodywork as delivered with the 2012 car for 2017 and for 2018 and beyond, within the standard bodywork as delivered with the 2018 Universal Aero-Kit. The exhaust exit locations must remain as specified by the aero-kit manufacturer.

TABLE B – Minimum Weight Part Exclusions / Inclusions

	Engine Weight
Turbocharger and exhaust	Excluded
Clutch	Excluded
Clutch actuation inc mounting studs	Excluded
Water radiators and accumulator	Excluded
Fuel pumps (except where mounted on or inside the engine)	Excluded
ECU and ignition unit	Excluded
Series mandated boost sensors	Excluded
Torque sensor	Excluded
Programmable devices and other electronic systems required by the engine	Excluded
Fluids	Excluded
Oil tank, coolers, and breather systems	Excluded
Studs for the purpose of mounting to the chassis or gearbox	**Included**
Heat Shields	Excluded
Ignition system components supplied with engine	**Included**
Inlet trumpets	**Included**

4 Homologation

4.1 **Homologation –** Only homologated engines may be used during the race season. However, Manufacturer test Engines may use non-homologated parts for test purposes. A homologated part may never be modified without prior approval by INDYCAR.

4.2 **Homologation date** – The homologation date for the Engine is to be completed by December 15th of the prior year. It is the responsibility of the Engine Manufacturers to ensure they work with INDYCAR to achieve homologation in a timely manner. The following homologated items may be homologated later as follows:

4.2.1 Exhaust systems must be homologated by January 28th

4.3 **Hardware –** Before homologation can be completed, an example of each of the components listed in Appendix D will be made available for inspection and secure storage by INDYCAR. A homologation document must also be completed.

4.4 **Bill of Materials –** A full bill of materials with graded parts to be explicitly identified with any alternate part specifications or assemblies must be supplied to INDYCAR.

4.5 **Drawings –** Before homologation can be completed, Engine Manufacturers will supply hard copies of engineering drawings of the items as shown in Appendix D. Drawings must include all relevant and expected part dimensional tolerances. Any tolerances missing from drawings are open to INDYCAR's discretion as to the appropriate tolerances. Parts found to be run outside these tolerances are open to failure and penalty following INDYCAR inspection.

4.6 **Torque Sensor –** To assist INDYCAR and ensure compliance with Homologation, Engines selected by INDYCAR will be run with a standard torque sensor that is fed to the INDYCAR-specified ECU for monitoring purposes. The measurement will not be available to anyone except INDYCAR.

4.7 **Engine Development –** Appendix I shows which seasons development changes may be introduced to homologated and which parts are allowed to have open development.

4.8 **Modifications to Homologated Parts** – Modifications to homologated parts including fabrication work on castings is strictly forbidden with the following exceptions:

4.8.1 Hand blending of replacement valve seats to the port may extend no more than 6mm into the port as measured from the valve seat-head casting interface and along the valve guide axis.

4.8.2 Applying approved coatings

4.9 **Open Development Item Inspection** – Open development items do not need homologating but may be retained and inspected by INDYCAR at any time for general compliance with the Engine Rules and Regulations (e.g. material type).

4.10 All parts homologated prior to Season Start may be used up to the Indianapolis 500® Mile Race. All Engines added to the Engine Pool for Full-Season Entrants for the Indianapolis 500® Mile Race and onwards must use homologated parts as raced in the Indianapolis 500® Mile Race.

4.10.1 Any parts from the prior season that are intended to be used prior to the Indianapolis 500® Mile Race must be declared at the time of Engine homologation.

4.10.2 Any parts not used in the Engine Pool during and after the Indianapolis 500® Mile Race lose their homologation and may not be installed in Engines without prior approval of INDYCAR.

4.11 **Reliability, durability and economic fixes –** Permitted at any time at the sole discretion of INDYCAR. A detailed description of such an upgrade will be circulated to all Engine Manufacturers who must respond within 5 working days.

4.11.1 Should any part be introduced as an approved homologation change, the Engine Manufacturer may, be required to provide an obsolescence plan for existing inventory if a homologation change plan is to use up existing parts. This plan should include remaining serial #s (if applicable) and quantities remaining in inventory and an estimated time for the old parts to no longer appear in fresh Engines entering the Engine Pool.

4.11.2 Approved changes to homologated parts may only be introduced prior to the Indianapolis 500-Mile Race if approved before the Homologation date or after the Indianapolis 500-Mile Race is complete if approved after the Homologation date for a given calendar year. Changes requested on the grounds of safety may be introduced earlier based on approval by INDYCAR.

4.12 **Performance upgrades** –2 weeks after the Indianapolis 500® Mile Race and again 2 weeks after the last Event of the Season, Engine Manufacturers whose Engines are statistically more than 4% deficient in power may, at the sole discretion and evaluation of INDYCAR, make improvements to be homologated immediately. These will be introduced only on new Engines being sent to the track. These improvements are allowed get the Engine up to 2% below the best-performing Engine. Should this 2% be exceeded, INDYCAR may elect to reduce performance standards to remain within the 2% window by means of boost or Engine speed control. In assessing Engine power deficiency, only measurements accumulated statistically during official INDYCAR timed on-track sessions will be used

5 Materials

5.1 **Definitions**:

5.1.1 *Metal matrix composites* – materials with a matrix material containing a phase of greater than 2%v/v which is not soluble in the liquid phase of the metallic matrix (examples include TiAl (TiAl is permitted for turbocharger turbine wheels)) NiAl, FeAl, CU_3Au, NiCo).

5.1.2 *Ceramic materials* – these are inorganic, non-metallic solids, examples include $A1_20_3$, SiC, B_4C, Ti_5Si_3, $Si0_2$, Si_3N_4.

5.1.3 *Inter-metallic materials* – these are materials where the material is based upon inter-metallic phases, i.e. the matrix of the material consist of greater than 50% by weight inter-metallic phase (s). An inter-metallic phase is a solid solution between two or more metals exhibiting either partly ionic or covalent, or metallic bonding with a long range order, in a narrow range of composition around the stoichiometric proportion.

5.2 **Prohibited materials –** Unless explicitly stated the following materials are completely prohibited:

1 Magnesium based alloys
2 Metal matrix composites (MMC's)
3 Inter-metallic materials
4 Alloys containing more than 3% by weight of Beryllium, Iridium or Rhenium.

5.3 **Exceptions**:

a) Except where otherwise stated, coatings and surface treatments are free from material restrictions providing that the coating thickness does not exceed 0.8mm surface thickness. Coating a previously homologated part does not nullify the homologation nor does it require re-homologation.
b) Spark plugs
c) Hybrid ceramic bearings are permitted in the following locations:
    1) Ancillary pumps (coolant and oil system)
    2) Gear train
    3) Alternator

5.4 **Mandated component materials** –

5.4.1 The following components must be made from ferrous alloy:
a) All fasteners except connecting rod bolts
b) Engine gears including gear hubs

c) Piston pin
d) Connecting rod and cap (must be the same material)
e) Crankshaft
f) Flywheel
g) Camshafts (single piece only)

5.4.2 The following ***must*** be made from ferrous, nickel, or titanium alloys:

a) Valves, valve springs and valve spring seats

5.4.3 The following ***must*** be made from monolithic aluminum alloy alloy:

a) Engine Block and Sump
b) Cylinder head casting (localized enforcement with either composite or MMC is prohibited)
c) Pistons

5.4.4 All additive manufacturing techniques are prohibited for construction of the following components

a) Cylinder Head
b) Cylinder Block, Sump and front / rear cover
c) Crankshaft, connecting rod, piston, pin, rings, flywheel, gears
d) Cams, cam gears, finger followers, tappet biscuits, valves, valve spring platforms springs

5.4.5 This regulation can be reviewed by the Engine Committee at any time and updated with a 24 month notice period. Criteria for change is primarily on cost – any proposed technique must be demonstrated to be cost neutral and IndyCar has veto. Should the regulation be changed on any component, that component will be eligible for re-homologation for the season following the notice period

5.5 **Lubricant** –

5.5.1 Engines must only use the following approved lubricating oils:

5.5.1.1 Shell 0w20 Part LP240002008

5.5.1.2 Shell 0w40 Part LP240004469

5.5.1.3 Oils previously Homologated ~~prior to~~ for the 2024 season through to the ~~Indianapolis Motor Speedway Road Course Event 5/11/2024~~ Nashville Speedway Event 9/15/24

5.5.2 An oil product must be used as-is and no additional chemical additives or treatments may be added to the product.

5.5.4 Conformance

5.5.4.1 Samples of engine oil from the car or containers can be taken by INDYCAR at any time during an event. Samples will be subject to analysis at an INDYCAR approved laboratory and checked for conformity by comparison with the approved sample.

5.5.4.2 Engine oil consumption must not exceed 0.85 quart/100miles.

6 Fuel Systems

6.1 **Injection Type –** All fuel injectors are to be electrically operated by solenoid mechanisms only.

6.2 **Number of injectors –** A maximum of two injectors per cylinder is allowed of which only one per cylinder may be used for direct injection.

6.3 **Fuel Pressure –** The maximum permitted fuel injection pressure is 300bar.

6.4 **Fuel supply –** INDYCAR will provide more fuel than is necessary to run at peak power mixture for each race (including parade laps).

6.5 **Fuel Composition** – The fuel will be E85 which will consist of a nominal mixture of 85 percent Ethanol, 15 percent gasoline and an additive package that is determined by INDYCAR.

See Appendix E for details and specific volume ratios of the fuel components. The fuel must be used as supplied by INDYCAR.

6.5.1 Any changes in fuel composition with regards to ethanol percentage, the gasoline component used, or the primary additive package requires notification to the IEC and will be applied on track only after consultation with the IEC, having provided IEC participants with suitable time to make the necessary updates and changes to their Engines to ensure safe and durable operation on track.

In a situation where an act of God or force majeure requires that an alternative source of fuel be used for an Event, INDYCAR will immediately notify the IEC members and make all reasonable efforts to ensure that the fuel specification is as close to the intended fuel specification detailed in Appendix E and that Engine

parameters can be suitably modified to ensure safe running.

7 Turbocharger Systems

7.1 **General –** Engines must only use two Borg Warner EFR7163 turbochargers, quantity (2), with a turbine housing A/R of 0.85. Entrants and/or Engine Manufacturers may not modify turbochargers from the manner in which they are received from the turbo manufacturer in any way other than clocking the compressor and turbine housings relative to the bearing housing, changing the connector on the optional speed sensor or changing the thread of the tapped boss on the turbine housing.

7.2 **Installation** – One identical turbocharger per cylinder bank; non-sequential operation

7.3 **Cooling –** The compressor housing may not be cooled by any method or substance other than the normal heat dissipated from the housing to the atmosphere or by ducted air.

Spraying or injecting of any substance into the compressor or onto the compressor housing is prohibited.

7.4 **Wastegate Operation –** Up to two (2) wastegates may be used per architecture and may be pneumatically or electrically operated but limited to poppet and flap valve types only.

7.5 **Anti-lag systems –** Anti-lag systems are prohibited**.** The Engine cylinders must be supplied solely with the air that has exited the turbocharger compressor(s). The turbocharger turbine(s) must be supplied solely with the combustion gases.

8 Air Intake

8.1 **Intercooling –** Inter-cooling by any means including fins on the inlet ductwork upstream of the plenum entry or entries is prohibited.

8.2 **Inlet Trumpets –** Only fixed-length trumpets are allowed. Adjustment of inlet length may be accomplished by the use of spacers or by fitting alternative lengths of trumpet.

8.3 **Variable geometry intake systems** – Any other means of varying the length of the intake (including, but not limited to, effective variation of inlet system resonant frequency by additional ductwork or volumes brought into play by valves or other flow regulating means) are prohibited. The intake must contain no moving parts apart from the compressor between the air filter and the plenum entrances.

8.4 **Heat Shields / Cooling Ducts** – Any heat shields or cooling ducts installed on the Car must not block visual access to the serial numbers on INDYCAR provided electronics, the manufacturer part and serial numbers on the turbocharger, nor the INDYCAR Engine seals.

9 Plenum

9.1 **Definition –** The induction system is defined as all parts related to the plenum chamber, intake runners, throttle mechanism that can contain the inlet air charge and fuel spray under all Race conditions without leaking.

9.2 **Plenum** – Only one plenum chamber is permitted. The plenum must be symmetrical side to side from the Engine centerline looking from plan view, with the exception of offsetting of the inlet runners to match the Engine bank stagger. The only purpose of the ducting between the turbo charger and the inlet plenum manifold must be to channel air. Ducts may not be configured to produce a reduced pressure at the mandated boost sensors. Spraying or injecting of any substance in this duct is prohibited.

9.3 **Plenum entrance** – Only one (1) air charge entrance to plenum per turbo charger is permitted. The minimum total air charge entrance area is 10,000mm^2 split equally between the entrances. The ductwork from the compressor outlet to the plenum must have no abrupt changes in direction or section. See Appendix A for details of the plenum pressure sensor location rules.

9.4 **Splitters –** Dividing or splitting the plenum into two chambers is prohibited. Turning vanes, vortex generators, panels or splitters which could direct air flow within the plenum chamber are prohibited.

9.5 **Cross-section –** Except for the throttle mechanism, inlet runners, fuel injectors, fuel rails, trumpets and typical corner radii, the plenum must be an open space having a constant cross section (perpendicular to the Engine center line) excluding plenum entrance. No additional partially closed off volumes to introduce resonances at particular Engine speeds are permitted. Inlet runners are to have smooth uninterrupted walls without side branches, except for the purpose of supporting throttle blades, allowing fuel to be injected and for the addition of pressure and temperature sensors.

10 Exhaust Systems

10.1 **Exhaust Length –** The exhaust system (including, but not limited to, primaries, collector, tail pipe etc.) must be of a fixed length. No moving parts, except for the wastegate poppet valves and turbine wheels, are allowed between the cylinder head exhaust face and the exhaust tailpipe outlet. Closed-end resonator chambers are prohibited.

10.2 **Homologation –** Homologation shall include the complete system, from the cylinder head exhaust flange to tailpipe exit (All other components are standard parts). No changes are permitted during an Event weekend without INDYCAR approval.

10.3 **Material –** Exhausts may only be manufactured in Inconel.

10.4 **Wall Thickness –** All exhaust components must have a minimum wall thickness of 0.036 inch (or 0.9mm).

11 Engine Throttles

11.1 **Throttle Pedal –** The throttle pedal and sensor actuation supplied with the chassis and the approved sensors specified in Appendix F must be used.

11.2 **Engine Throttles –** Engine throttling is by port butterfly only and must be located in the intake runner. The number of throttles must equal the number of cylinders. Only one throttle per cylinder is permitted.

11.3 **Engine Throttle Measurement** – Engine throttle percentage reported in the ECU must correspond with the minimum and maximum exposed open area of the throttles with 0% corresponding to the minimum area and the 100% corresponding to the maximum area.

11.4 **Torque Control –** The only means by which the Driver may control the Engine torque is via a single chassis-mounted foot pedal or on-board fuel mixture switch. Designs which allow specific points along the pedal travel range to be identified by the Driver or to assist in holding a position are not permitted.

11.4.1 The minimum and maximum pedal travel positions must correspond to the Engine throttle minimum (normal idle) and maximum open positions with the additional following requirements:

a) The Engine throttle must never be decreasing with increasing pedal travel for a given Engine speed with the exception of circumstances specified in 11.4.2.

b) Off pedal Engine throttle position must be constant while on track and Engine idle control is not engaged.

c) Idle control may only differ by +/- 2% from the off pedal Engine throttle position.

11.4.2 It is permissible to take control of the Engine torque away from the Driver during any of these events only:

a) When a stuck throttle is detected

b) During a gearshift

c) For pit lane speed limit control

d) For Engine rotational speed maximum limit control

e) To control over boosting

f) For idle Engine rotational speed control

11.5 **Throttle Angle Variation –** There can be no more than a 2% throttle angle variation bank to bank between the Engine throttles at any time.

11.6 **Drive-by-wire System –** Drive-by-wire (DBW) by electro-mechanical system only is mandatory. A maximum of one DBW motor per cylinder bank is permitted.

11.7 **Throttle Return Spring –** The Engine throttles must feature a mechanical spring return mechanism capable of shutting the butterfly throttle in the event of a DBW motor failure.

11.8 **Throttle Safety System –** The Engine Manufacturer must be able to demonstrate that the systems to detect and react to a stuck throttle condition are effective. These systems must be operational whenever the Car runs during an Event.

12 Control and Logging Systems

12.1 **Traction control –** Traction control is the use of any electrical device or control on the Car to limit or control the traction of or torque delivered to the rear wheels in a manner not directly and continuously controlled by the Driver or not to the engine torque limits available to the Driver at all other times on track. Launch control is the use of traction control from a Car in a stopped position to accelerate the Car moving forward. Traction or launch control is not permitted.

12.2 **Anti-Stall** – Anti-stall must be set to operate effectively in, at least, 2nd and higher gears. The Driver may disable it under yellow conditions by using the rotary-switch.

12.3 **ECU –** Only the standard INDYCAR ECU, manufactured by McLaren Applied Technology (MAT) and supplied by INDYCAR may be used. The standard INDYCAR ECU will be the TAG 400i. Running on track with an ECU that does not contain the designated software version protection is not permitted during any INDYCAR-sanctioned Event.

INDYCAR reserves the right to inspect, draw data from, and withhold any INDYCAR ECU at any time.

12.4 **Standard Hardware –** Tampering with the ECU, boost sensor, or torque sensor as provided by INDYCAR is not permitted.

12.5 **Software –** The control software running within the TAG-400i will be written by McLaren Applied Technology, MAT (formerly McLaren Electronic Systems Ltd). Engine Manufacturers will be able to tune the various maps and configuration parameters to suit the requirements of their Engines. Engine Manufacturers will be able to develop their own versions based on the Race specification software for Engine test bed and rig test use on unlocked ECUs, but may not use that software on any INDYCAR ECU at any INDYCAR sanctioned event; however, allowances for Engine Manufacturer tests can be made with prior approval from INDYCAR and only in Cars running unlocked ECUs.

12.6 **Software change requests –** Any software request from an Engine Manufacturer for implementation at any sanctioned event must be accompanied by a detailed description of its purpose and its intended function. INDYCAR will circulate it to all Engine Manufacturers who will have 5 working days to respond. It will then be submitted through the process setup by MAT (web portal). INDYCAR will need to approve it prior to implementation by MAT. In some cases, an approved software request may not be possible for McLaren to implement.

12.7 **Firmware –** The INDYCAR specified ECU will be mandated containing locked low-level firmware developed by the suppliers of the control units. All other homologated units must use the firmware provided by the supplier with the version declared to INDYCAR. It is not permissible to modify the firmware on any approved control unit. Updates from the supplier of the unit are permitted as long as INDYCAR are notified ten (10) working days before application. Calibration settings may be adjusted on the control units as long as the firmware version is not changed. Any firmware updates will be simultaneously available to all Engine Manufacturers.

12.8 **Functionality –** Control functionality (including boost monitoring) will reside within the ECU and clutch control unit (CCU) only. No driver box, such as an injector driver, ignition driver, DBW motor driver, or wastegate actuator may provide any control function.

12.9 **On-board Communication between Control Units -** The INDYCAR-specified ECU will provide a bi-directional data link for on-board Car data logging and an additional link for the dashboard through a controller area network (CAN). The assignment of the data channels is open to specification by the Engine Manufacturer. The use of and wiring of such communications lines beyond CAN requires INDYCAR approval.

12.10 **Function adjustment –** Any selection of or adjustments to control functions must be initiated by the Driver via on-board switches only.

12.11 **Two-way telemetry –** Two-way telemetry or remote control of any software function while the Car is on Track is prohibited.

12.12 **Pit lane Speed Control –** Only the Driver and no automated program or control may initiate pit lane speed control activation and deactivation.

12.13 **Boost Pressure** – The ECU application layer software for monitoring the plenum pressure via the two series supplied transducers is controlled by INDYCAR. The penalty for exceeding the plenum pressure levels as specified in Engine Regulation 3.3 will be determined by INDYCAR and whose execution may be enforced by (but not limited to) the ECU.

12.14 **Engine Crankshaft Rotational Speed Limiter –** The ECU application layer software for imposing the series mandated Engine speed limit is controlled by INDYCAR, as

defined previously in Engine Regulation 3.2.

12.15 **Quarantine –** INDYCAR reserves the right to impound ECU's at its sole discretion.

12.16 **Fuel Mixture Switch –** A single rotary switch to be located within the cockpit and controlled physically by the Driver. It may have a maximum of eight (8) discrete selector positions. The switch function is selection of a specific combination of Engine control parameters and maps for fuel, ignition and plenum pressure control. The switch may only send out the physical selected position by the Driver, and the ECU may only receive the intended selection from this switch and not by any other device or circuit.

12.17 **Diagnostic Switch –** A single rotary switch to be located within the cockpit and controlled physically by the Driver. It may have a maximum of eight (8) discrete selector positions. The switch function is to allow the ECU to disable select Engine inputs or sensors and set failsafe operation for specific ECU functions. The switch may only send out the physical selected position by the Driver, and the ECU may only receive the intended selection from this switch and not by any other device or circuit.

12.18 **Crankshaft Rotational Speed Sensor –** A McLaren Electronics Inc. crankshaft speed sensor is mandated, order part number **O 030 350 001 148** – see Appendix G. Any attempt to interfere with or modify the signal from these sensors as seen by the ECU will be subject to penalties.

12.19 **Cylinder Pressure Measurement –** No form of direct cylinder pressure measurement is permitted, including, but not exclusive to, ion current detection.

12.20 **Wiring –** Engine loom and interface loom wiring must be approved by INDYCAR before being used in an INDYCAR-sanctioned event.

12.21 **Gearshift Control** – The gearshift control must only be used with the bespoke purpose of shifting the gearbox only. Any attempt to use the ECU control for purposes other than managing the Engine and gearbox to shift from one gear to an adjacent gear is prohibited.

12.22 **Voltage Regulation** – The alternator must supply enough to current to maintain an electrical system power supply voltage of 13 Volts at all times while on track.

13 Transmission

13.1 **General –** The transmission, including the clutch mechanism, is provided as part of the safety cell/rolling chassis and as such is standard for all Competitors. It features gear actuation by the INDYCAR-specified pneumatic gearshift control system. Tampering with or modifying these systems is prohibited.

13.2 **Control –** Control for the gearshift system will be through the INDYCAR-approved ECU

only and must only be initiated physically by the Driver by paddle switch with the exception of the fuel probe sensor control in the ECU.

14 Side-pod Inlet Ducts (2024 Season and beyond)

14.1 **Blocker Panels –** Dallara provide separate left hand right hand sidepod inlet duct blocker panel blanks. These blocker panel blanks may be cut to provide up to four (3+1) different options of inlet blockers for each side. The modified blockers do not have to mirror each other from left to right giving a possible total of eight (6+2) unique parts, which must be homologated. Please see Appendix H for limitations to how the blockers may be cut.

14.2 **Inspection** – The Engine Manufacturers are responsible to providing inspection tools for the blocker panels in the form of a Go / No-Go gauge tool. The design must be presented at the time of homologating the blocker panel. The tools must be delivered to INDYCAR before the season start.

14.3 **Homologation** – For the 2024 Season, the Engine Manufacturers must homologate their sidepod inlet blockers.

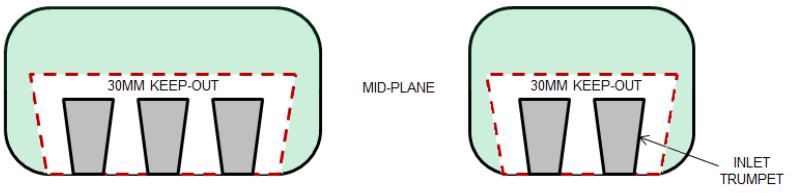
14.3.1 Homologation consists of submission of CAD for the proposed parts in addition to the homologation form.

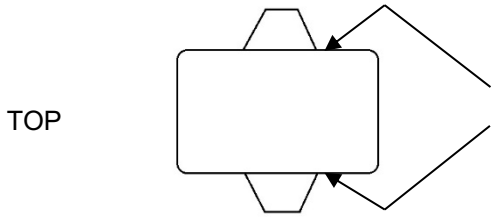
14.3.2 Homologation should be completed by the following dates

a. Three (3) pairs by March 7th 2024
b. One (1) additional pair by May 1st 2024

Appendix A Boost sensor location

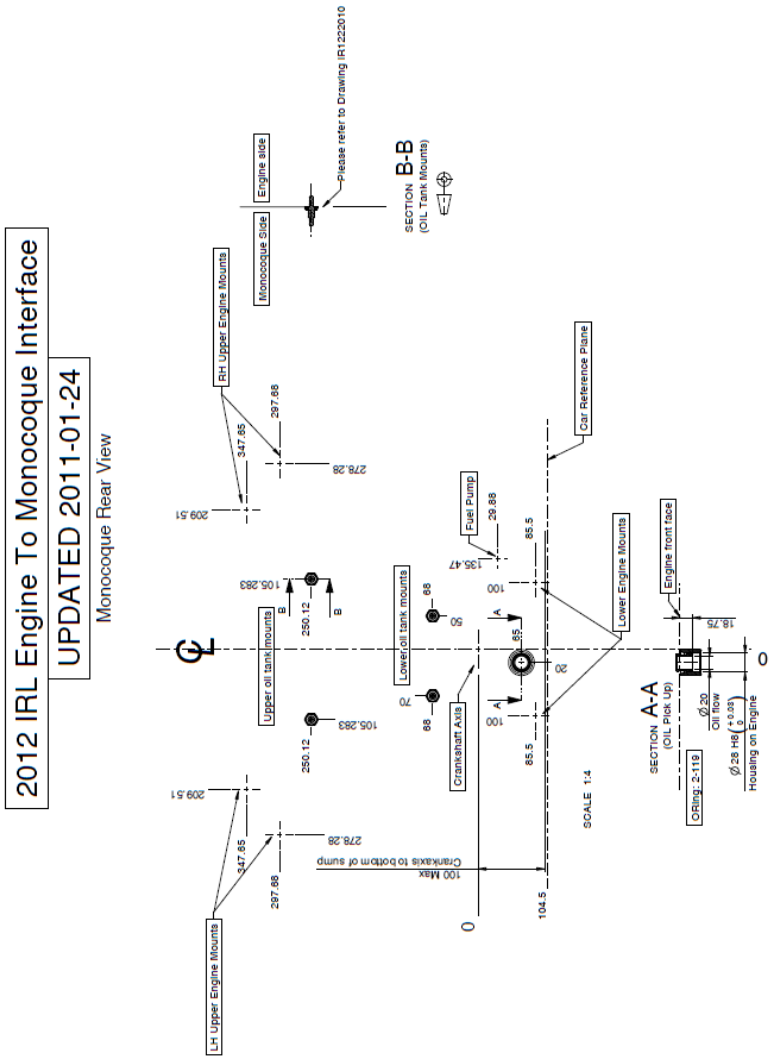
1. Two, single-channel sensors as provided by INDYCAR are required per installation.
2. Each sensor must be mounted on the same face of the plenum as and coplanar with a plenum inlet. Adjacent to each plenum entrance must be a flat area of minimum dimensions of 55mm x 25mm on the same plane as the joint between the duct and plenum and between 90° ± 20° to the locus of the centroid of the last 15mm of the duct cross-sectional area. These flat areas will be used as mounting locations for the INDYCAR-supplied plenum pressure sensors.
3. Sensors must be located within 50mm of the nearest point of the junction between the plenum inlet(s) and the inner surface of the plenum.
4. Sensors must be located at least 30mm away from any portion of the Engine inlet trumpets (see below).
5. Plenum must have a Ø4.0mm ±0.1mm orifice to mate with the sensing port of each sensor and the mounting face of the sensor must be no less than 11.0mm from the inner surface of the plenum. The axis of this hole will be 90° to the flat area surface. The inside of the plenum where the sensor mounts will be flat ± 0.1mm within 15mm of the axis of the hole.
6. Sensors must be easily accessible without the removal of any other Engine components.



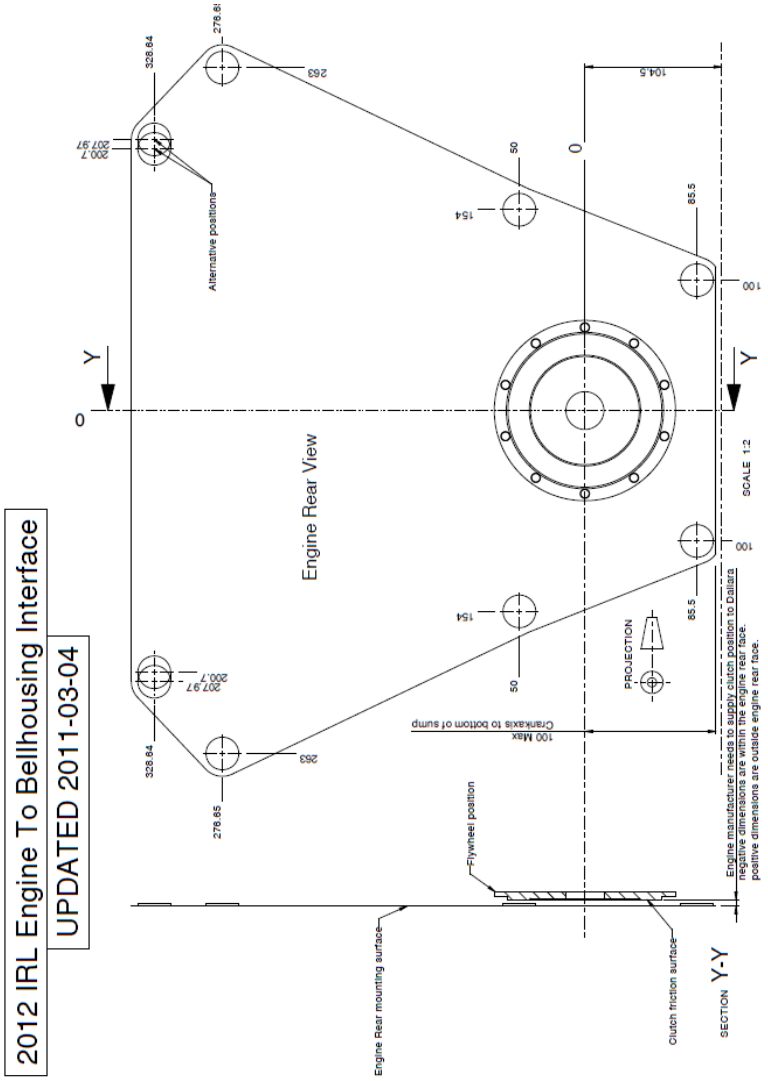


Plenum pressure sensor to be mounted on these faces of

Appendix B Engine to chassis interface points



Appendix C Engine to gearbox interface points



Appendix D Reference components

The following components will be held in secure storage: -

- Left and right cylinder heads complete with one cylinder's valves, camshaft followers, camshaft bearings and camshafts. These are to be fitted using light springs, not the production valve springs, to allow valve lift vs. camshaft angle to be measured.
- Cylinder block including sump
- Plenum upper and lower
- Compressor inlet and outlet air ducts *
- An example of each different design of fuel injector – Indirect and direct

* Note: The above marked items will be held in secure storage at the INDYCAR corporate offices.

Hard copies of drawings of the following components will be held in secure storage: -

- Cylinder sleeve
- Connecting rod
- Crankshaft
- Flywheel
- Inlet and exhaust manifold faces of cylinder head
- Inlet and Exhaust camshaft blank
- Camshaft followers
- Inlet and Exhaust valve lift profile
- Inlet manifold
- Throttle body and butterfly
- Fuel rails – Indirect and direct
- Engine loom(s)
- Interface loom

Appendix E E85 Typical Properties

Test Method		Result	Units	Lower limit	Upper Limit
Color	Color	Clear, Bright and Free of entrained matter			
D6304	Water content	0.677	wt%		1
Physical Properties					
D5191	Vapor Pressure	6.5	psi	4	7
D4052	Specific Gravity	0.774		0.77	0.79
Distillation					
D86	10%	157.64	°F	154.6	162.6
D86	50%	171.5	°F	168.5	174.5
D86	90%	172.8	°F	169.8	175.8
Chemical Analysis					
D5501	Ethanol	82.95	wt%	82.99	83.99
D5501	Oxygen (Calculated)	28.96	wt%		

*Specific information available upon request

** Fuel is additized with Keropur 2100 at the treat rate of 1.135 ml/gallon

** Fuel includes Ethanox 4737R at a treat rate of 0.1 ml/gallon to help with storage stability

*** All fuel specs must be mutually agreed upon

Appendix F Throttle Pedal Position Sensor Specification

Cosworth P/N 21A-0180

or McLaren Applied Technologies P/N O 030 370 021 100

Hall Effect

0.5V = 0°

30° = 4.5V

D-shaped interface

Twin-track, opposing electronic range

Appendix G McLaren Crank Speed Sensor Specification

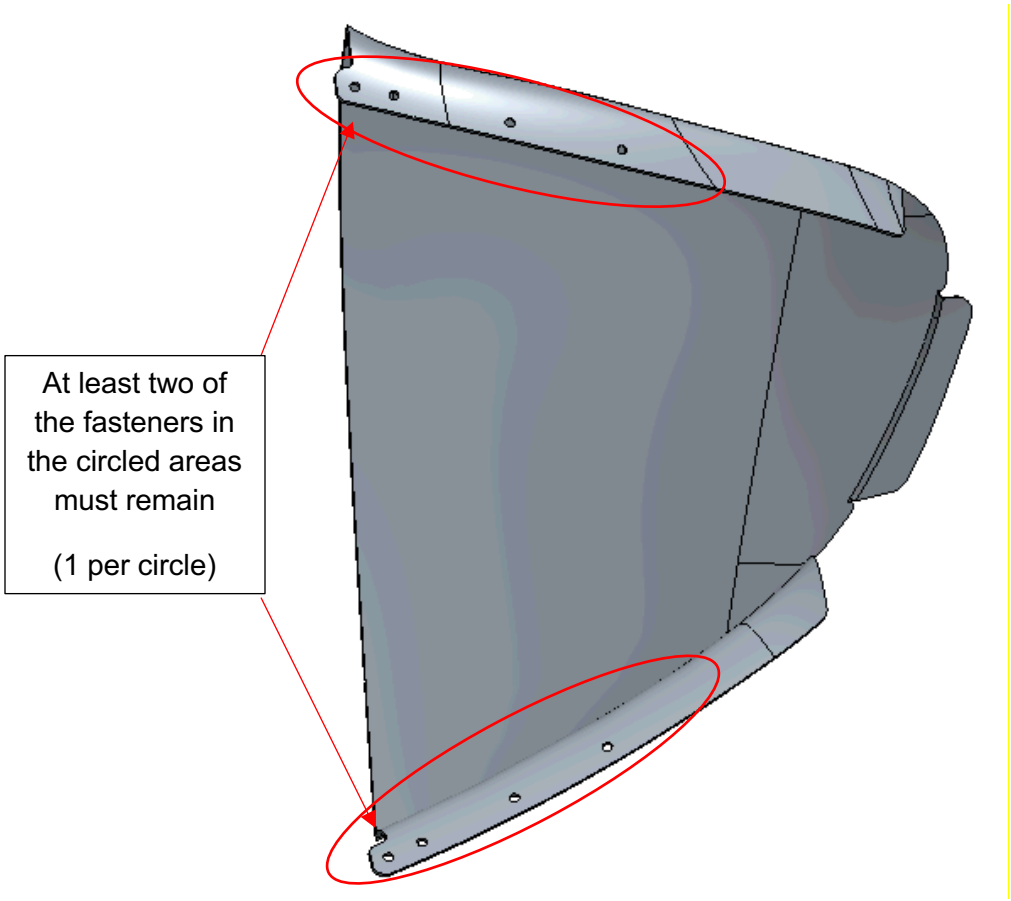
DRAWING PENDING

Appendix H Side Pod Inlet Blockers

The Dallara side pod inlet blockers include the following parts:

Description	Qty	Part Number
Side pod inlet blocker (left hand)	1	IR1802A011
Side pod inlet blocker (right hand)	1	IR1802A010

The homologated modified blockers may cut the main panel in any shape required as long as at least two (2) fastener holes and the insert tab (highlighted below) remain intact.



Appendix I Engine Part Homologation Schedule

	Fixed	2024	2025	2026	Open
Chassis mounting points	O				
Gearbox mounting points	O				
Engine length	O				
Deck height	O				
Gear train	O				
Crankshaft including journal sizes and Pin angular position	O				
Cylinder block, sump casting and machining	O				
Cylinder head casting, cam cover	O				
Turbo specification	O				
Valve train layout	O				
Camshaft blank	O				
Lubrication system (excluding piston squirt jets)	O				
Cooling system contained within the engine	O				
Water pump	O				
Oil pressure, scavenge and oil-air separator pumps	O				
Engine auxiliaries	O				
Cylinder head: valve angles, valve center line spacing, location of intake and exhaust ports relative to the flange face, spark plug location, injector positions, camshaft and journal location, intake/exhaust port shape†, combustion chamber shape, valve seat and guide	O				
Induction system, plenum	O				
Fuel Injectors	O				
Camshaft (lift, duration, and followers)	O				
Cylinder Sleeves	O				
Coils	O				
Alternator	O				
Fuel System (pumps, rails, fuel lines, and all fuel wetted parts from the Engine dry break to the injectors)	O				
Engine Electronics Mounting Trays (ECU, Injector Driver, Ign Driver, etc.)		spec			
Sidepod inlet screens		spec			
Air filter		spec			
Lubricating Oil x 2		spec			
Turbo inlet ducting (low pressure)		spec			
Blocker panels (3 option cuts per side Start of Season + 4th option May '24)		O			
Turbo connection pipe (high pressure + connector to filter)		Two times			
Exhaust system including primaries, secondaries, and tail pipes (including Wastegates)		O	O	O	
Connecting rod and bushing		O	O	O	
Piston, rings, wrist pins and circlips (including compression ratio)					O
Approved coatings/surface treatments					O
Valves, valve springs, retainers and spring seats					O
All bearing shells and piston squirt jets					O
Spark plugs					O

Appendix J Clutch Slave Diagram