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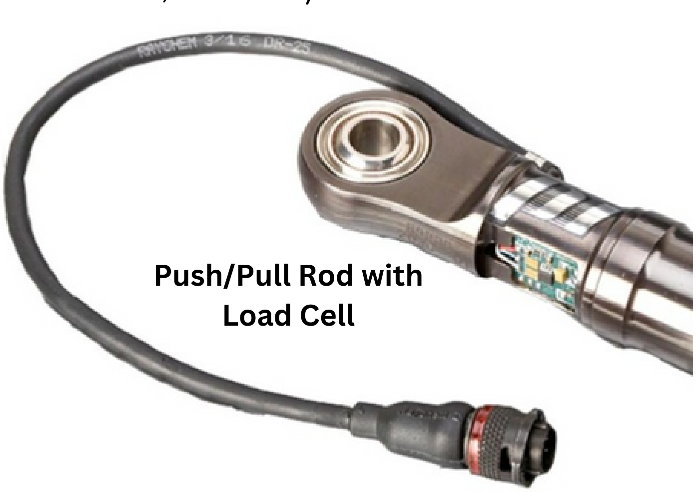
WHAT F1 AERODYNAMICISTS CONSIDER DURING PRE-SEASON TESTING

During F1 pre-season testing, teams are putting their newly designed racecars through their paces and verifying the characteristics prior to the departure for the first group of races. From a design and mechanical point of view, continuous checks will be made to find and eliminate potential showstoppers. In parallel, data will be being combed through to obtain all the necessary information needed to ensure low lap-times for qualifying and race.

From an aerodynamic development point of view, the team needs to be sure that the expected performance gains have translated to the track. Since aerodynamics is key to performance, it should be of no surprise to hear that considerable time and effort is dedicated to correlating track data to the two primary aero development tools, Wind Tunnel and CFD.

There are three main aero correlation techniques.

The first of these involves measuring aerodynamic force. Typically, strain gauge load cells are designed into suspension geometries and through a set of equations, the loads are resolved into forces and ultimately downforce coefficients at the front and rear wheel centrelines. By analysing these forces with varying speeds, ride heights and roll/yaw/steer angles, the necessary correlation can be made. With this method, we can pick out track related aeroelasticity and degradation, frequently associated with part integrity and construction or should it manifest, an aerodynamic stall.

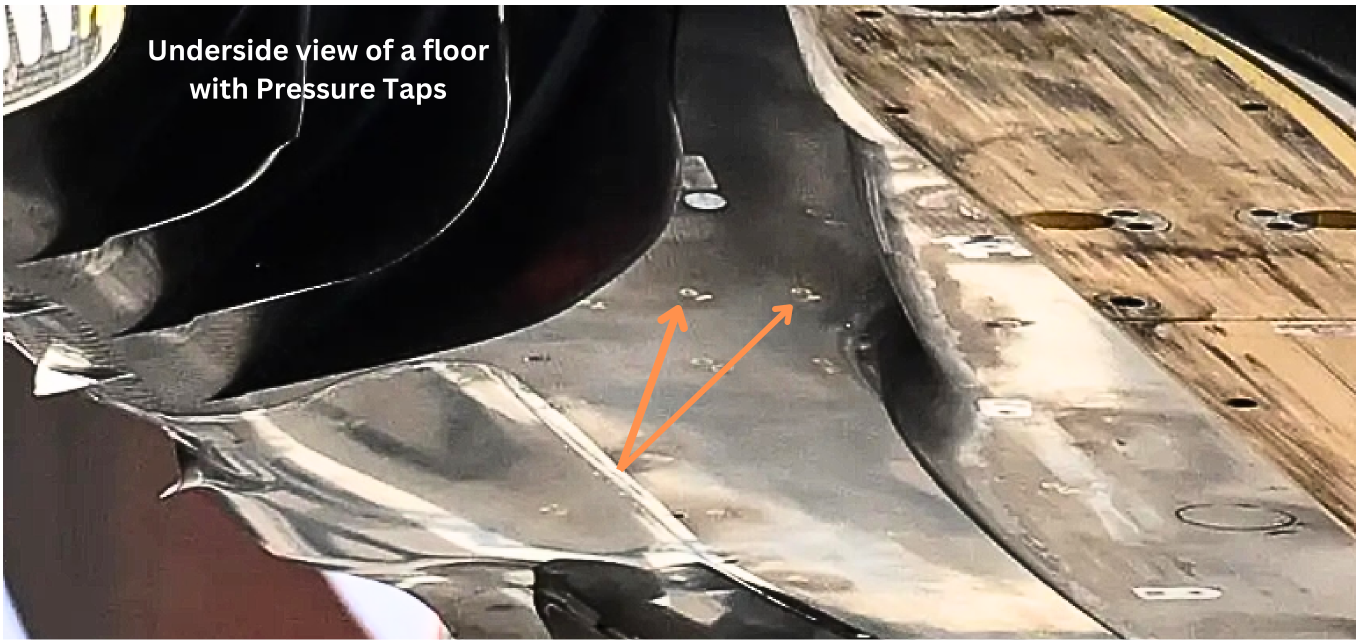


The second technique is based around the measurement of pressure and the unique relationship which exists between pressure and velocity. Pressure probes provide a conveniently simple, mobile and robust tool for the exploration of flow. From the simple Total-Pressure probes we would bend from brass tubing during the early years, these days F1 cars can frequently be seen with rakes consisting of hundreds of the higher accuracy “shrouded” Total-Pressure probes, frequently referred to a Kiel Probes. We’ve been using these rakes for some years now to capture larger areas of information, despite their obstruction within the airstream. Strategically placed, these frames can shed light on wheel wakes, energy of flow fields and flow directions for the real-world environment. Those crucial snapshots are then compared to CFD simulations and Wind Tunnel data to reassure that all is well for the future development processes.


A single Kiel Probe

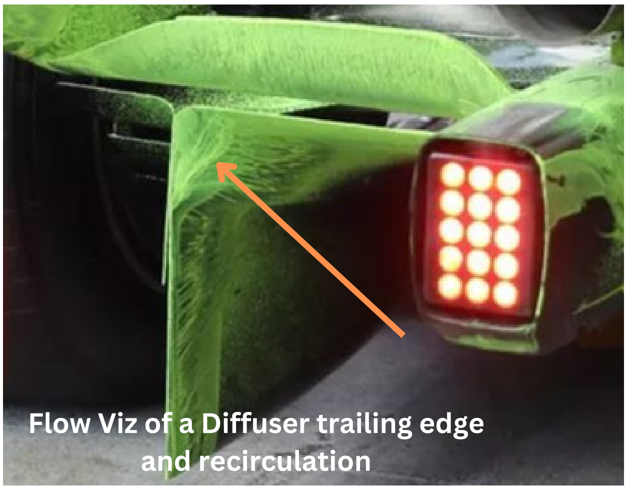
Out of sight will often lie the Surface Pressure Probes we refer to as Pressure Taps. These small openings sitting flush to bodywork and placed over an entire area of let’s say, the underside of a floor, aim to capture the pressure distribution on a surface. Whilst we aim to keep the “working” side as clean as possible, on the inside lies every mechanics headache. Each Pressure Tap is routed with mix of tiny brass, steel and PVC tubing along a designed path to a block of pressure transducers to record the pressures exerted on the working surfaces. It’s exactly those negative forces that keep the race car “stuck to the track” and push the cornering speeds higher, and hopefully lap times lower. As before, the floor pressure distribution information from the race car on track will be measured against the development tools at HQ for future optimisation of both the car and development processes.

If Pressure Taps are a headache for mechanics, the third technique we adopt is truly a nightmare for them! By mixing a pigment (normally a powdered fluorescent dye), a solvent such as paraffin and an oleic binder, we cook up our Flow Viz paint! Armed with this cocktail, we aerodynamicists spray or paint the surface of interest seconds before the racecar exits the garage. In the right hands, this technique will register patterns and characteristics of the flow over a surface,


Underside view of a floor with Pressure Taps

when dried by the airspeed over it. Once the racecar is back in the garage, we can identify areas of separation, turbulence, vortices and streamline patterns. Often, this paint can be seen on floor diffusers, as the designed parts generally have a minimal thickness towards trailing edges and therefore undesirable zones for Pressure Tap usage.

Classically, Flow Viz is used to gain a comprehensive understanding of wing surfaces. The Flow Viz image below shows an example of a wing suction surface with airflow direction from left to right. Initially, coarse parallel lines are visible in the flow direction up to approximately 35% chord, indicating a laminar flow regime. Beyond the 35% chord, a speckled pattern emerges, showing the transition zone and its increased turbulence. After the transition line at 65%, the flow becomes fully turbulent and remains attached.


Flow Viz of a Diffuser trailing edge and recirculation

The photos of Flow Viz are then used to validate CFD & WT . By comparing the visual results with the numerical simulations, we can ensure that those models are accurately representing the physical flow phenomena.

The upshot of good correlation is confidence in the development program offering continued improvements in aerodynamic performance & stability.