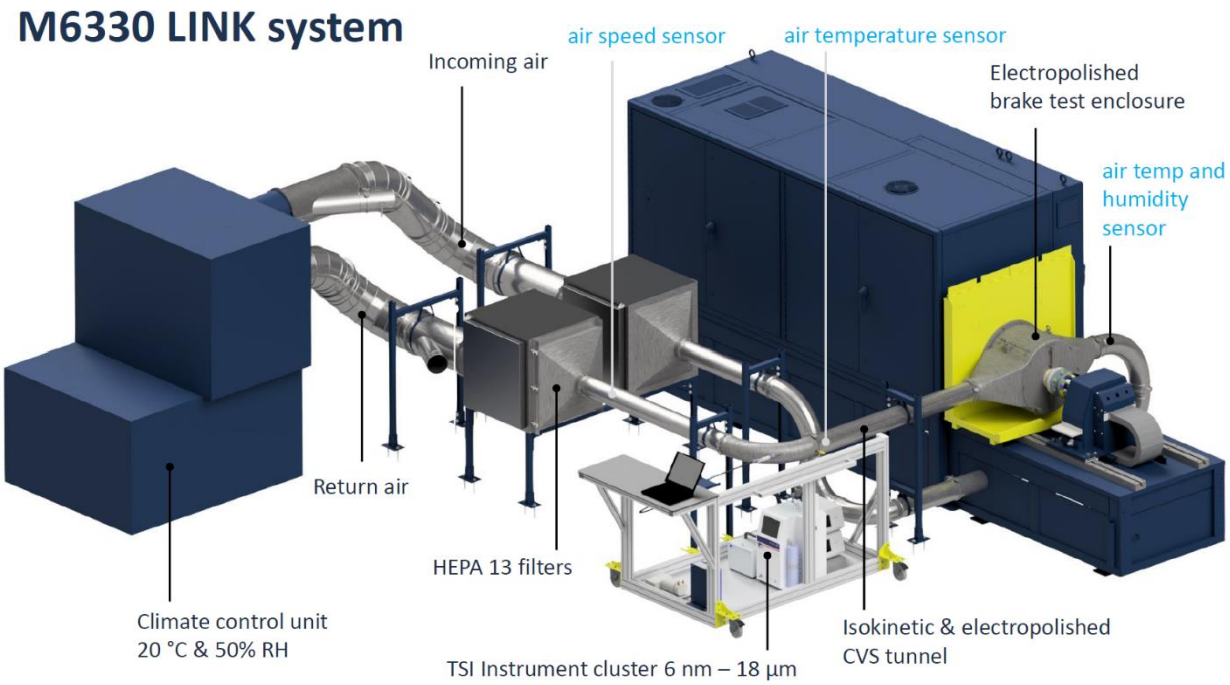
M6330 LINK Brake Emissions System

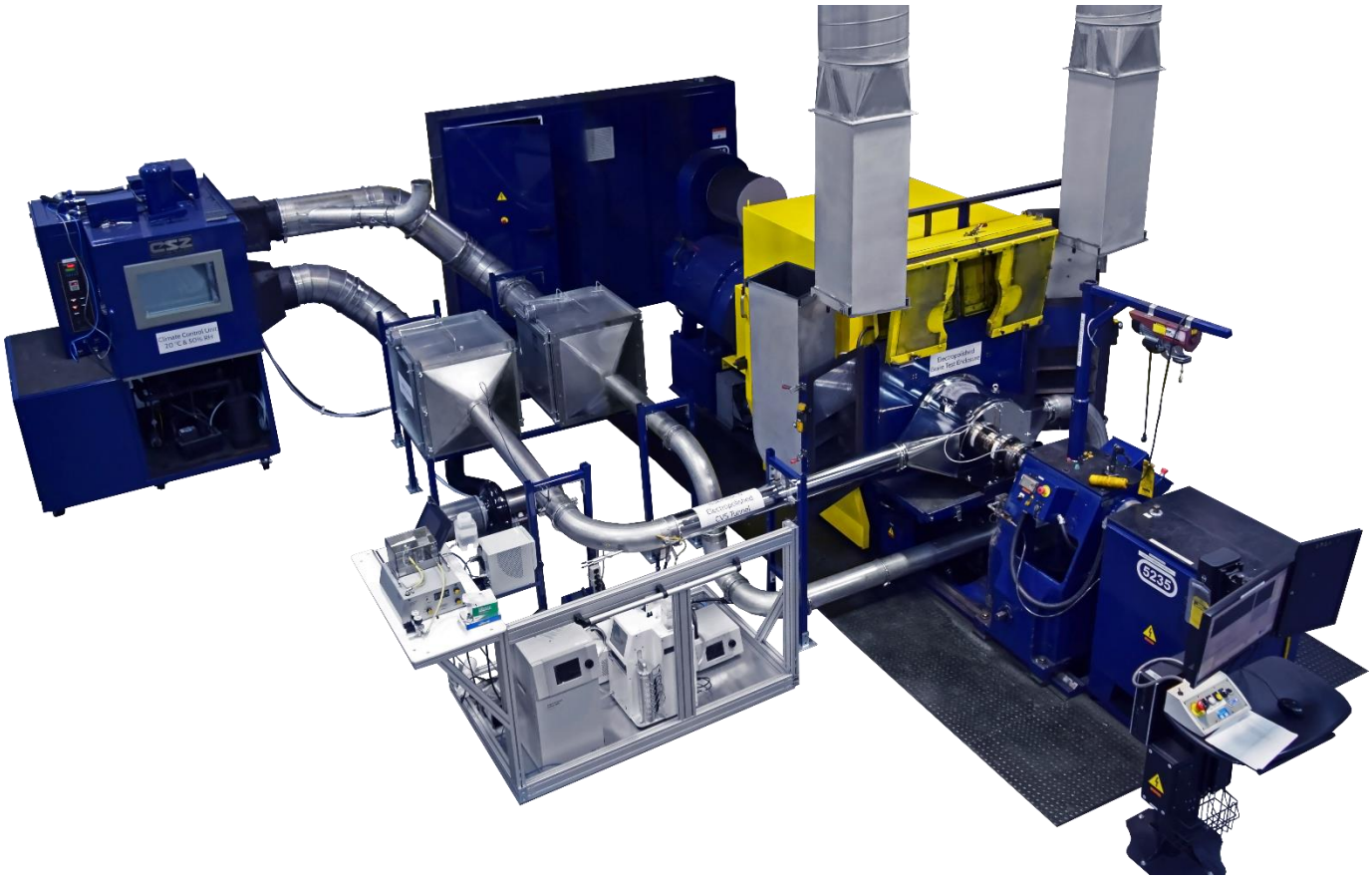
List of included Items:

- Climatic Conditioning Unit
- HEPA Filters (inlet and outlet)
- 150mm Diameter ducting system for inlet and outlet (from HEPA Filters to Brake Enclosure) (ducting support stands included)
- TSI Instrument cart (extruded aluminum)
- TSI Instrument analyzers (dependent on options purchased)
- Iso-kinetic & electropolished brake enclosure
- Air temp and humidity sensors

*Incoming and Return air ducting to the CCU is not provided. This is provided by customer and based on facility layout.



Model 3000 Specification



General Process Description

The Brake Dynamometer operates duty test cycle using customer brake parts with fixture provided by LINK.

CCU provides conditioned air per ISO standards into first HEPA filter. Conditions are driven to ensure table conditions for brake output and air stream conditions for debris sampling.

Conditioned air is passed through the first HEPA 13 filter to meet clean air levels and remove volatiles prior to brake enclosure.

Air speed, flow rate, temperature and humidity are measured at enclosure entry.

Stainless steel brake enclosure is designed to limit turbulent airflow conditions. There is electropolish surface treatment on the inside of the walls.

Dust particles exit the enclosure and stabilize in the straight duct section before sampling. Per EPA method.

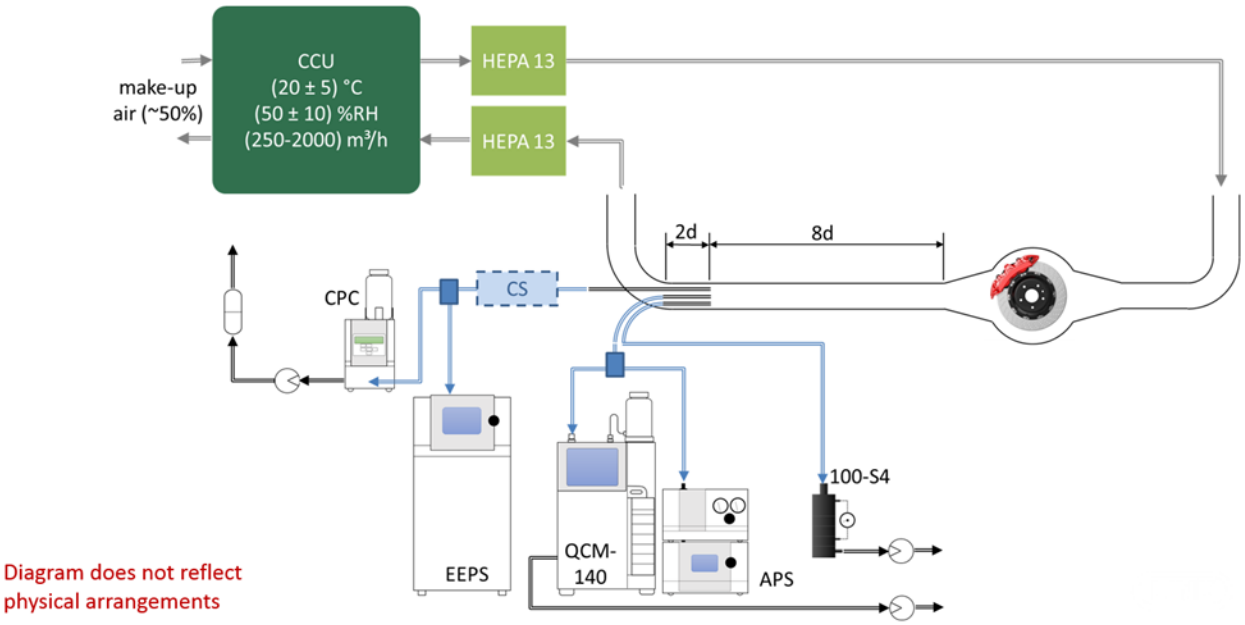
Sampling outlets for CPC, EEPS, APS , QCM , Mousi Impactor are taken after 2 diameters following 8 diameters of straight length.

Instrument cart houses all TSI analyzers and workstation.

Air speed, flow rate, temperature and humidity are measured on outlet prior to HEPA return filter.

Return EPA filter minimized brake dust deposits in the CCU and blowers.

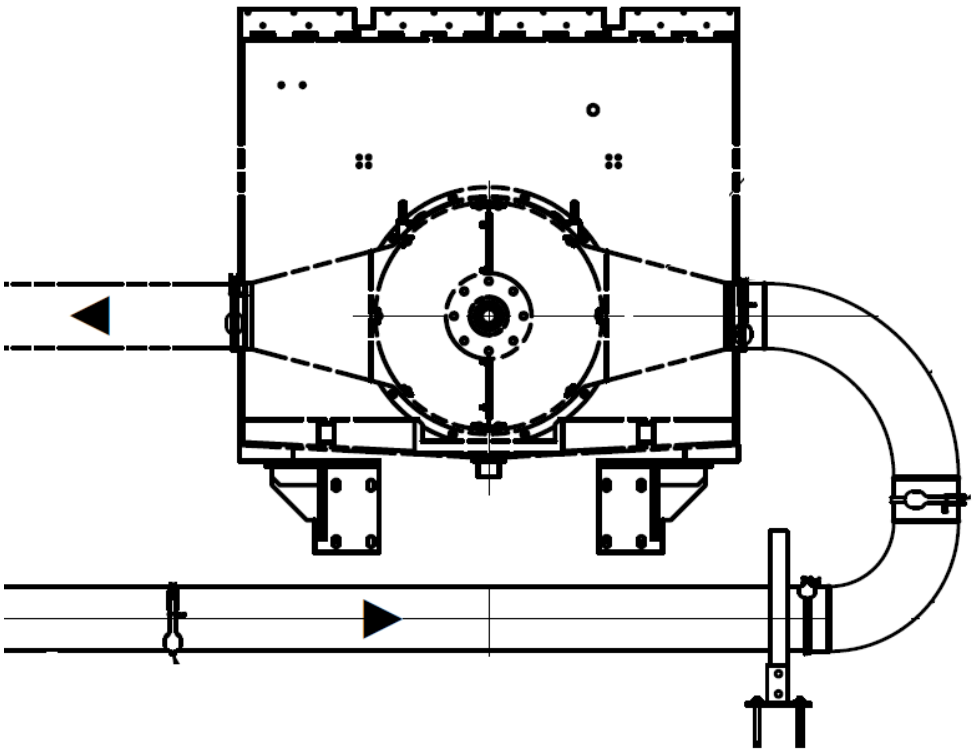
6330 LINK system



Link Brake Emissions Enclosure

The horizontal sample tube and brake emissions enclosure allows for testing of particulate mass with the standard TSI emissions sampling suite. 150 mm duct openings on either side allow cooling air to flow across the test area. There is an opening in the enclosure for the dynamometer driveshaft to enter the chamber. All penetrations through the enclosure have been sealed as well as possible to minimize air and dust exchange between brake enclosure and the lab. The enclosure has access and panels are moveable to allow maximum access to the testing area. The maximum usable inside dimension in the emissions enclosure is about a 10.5” radius.

Brake testing often requires the use of water and high humidity conditions, so all within the enclosure is stainless steel, with internal electropolished finish, with minimal constrictions and with at least 8 diameters without disturbances prior to brake emissions sampling and prior to measuring the cooling airflow (standard pitot tube). This item follows the U.S. EPA method 1A regarding sampling and airflow measurement positions. Air temperature and humidity measurement is taken at the outlet pitot tube in outlet duct. Temperature inlet is measured prior to entry into brake enclosure.



Link Brake Emissions Climatic Conditioning Unit Requirements

The brake emissions climatic conditioning unit (CCU) is used to control the temperature, humidity, and air speed at the brake test area. Airflow can be controlled in Environmental with Recirculation Mode.

Air pressure in the brake test area is to be set to a slight negative pressure relative to the lab atmosphere. This prevents dust from escaping the enclosed test area and entering into the lab atmosphere. In this mode, air is recycled within the system, run across the test area at the variable speed, and returned back through the ductwork.

An anemometer is provided for air speed feedback and a temperature/humidity sensor for temperature and humidity feedback.

Using the Brake Emissions Climatic Conditioning Unit on a Link Engineering Company (LINK) performance dynamometer also requires a brake emissions enclosure to maintain specified temperature and humidity setpoints at the brake.

CCUs are capable of consuming a large amount of three phase electrical power. Typical units can draw in the range of 125 kVA. Because of variations in the technologies used and options selected, the exact electrical power requirements cannot be determined until after an order is placed.

Link Brake Emissions Climatic Conditioning Unit	
Temperature	20 °C ± 5 °C
Temperature Control Stability	± 0.5 °C (0.9 °F)
Humidity	50 % Relative Humidity
Humidity Control Stability	± 10 % Relative Humidity
Minimum Airflow	250 m^3/hr variable speed
Maximum Airflow (Environmental Off)	2000 m^3/hr variable speed
Airflow Control Stability	± 5 % Steady State
Interior Noise to Chamber	≤ 70 dB
Exterior Noise @ 1 m	≤ 75 dB
Electrical Power Requirements	To be determined after an order is placed

TSI Inc. Particulate Sampling Equipment

The specifications that can be met by the PM sampling system are:

- Brake emissions measurement in real-time at (1 to 10) Hz during, and in-between brake events
- Particle size distribution from 5.6 nm to 20 µm
- Gravimetric sampling at nine steps from 45 nm to 20 µm
- PM size classification capabilities at PM1.0, PM2.5, and/or PM10
- Particle concentration in real-time from 1 Hz to 10 Hz, depending upon the particle size range as a function of the instrument(s) utilized;
- Particle concentration capability down to 1 particle/cm^3
- Continuous recording of brake emissions during brake events, and in-between when the brake is not being applied
- Data exchange between the TSI system and ProLINK controls

The TSI Inc. measurement systems that will be used in this work are depicted below. The systems are shown along with their component names as well as their particle measurement size range, along with whether they measure mass or count (#).

100S4 – Gravimetric sampler (PM<1, PM1.0-2.5, PM2.5-10, PM10-18, PM>18)

low-pressure impactor that collects debris (end-of-test) on 47-mm filters for PM

Basic Unit CPC – Condensation Particle Counter (continues from ~23 nm to ~2.2 µm)

number concentration by growing particles and measure via light scatter

APS – Aerodynamic Particle Sizer (0.37 µm to 18 µm)

real-time Particle Size (PS), Particle Number (PN), and PN concentration using time-of-flight between lasers

EEPS – Electrodynamic Particle Sizer (5.6 nm to 560 nm)

real-time particle size distribution using electric charge levels into multiple electrometers

QCM – Quartz Crystal Microbalance (continues from 45 nm to 2.5 µm)

real-time gravimetric sampling using first-principle method for change in mass over time

Model 3000 Specification

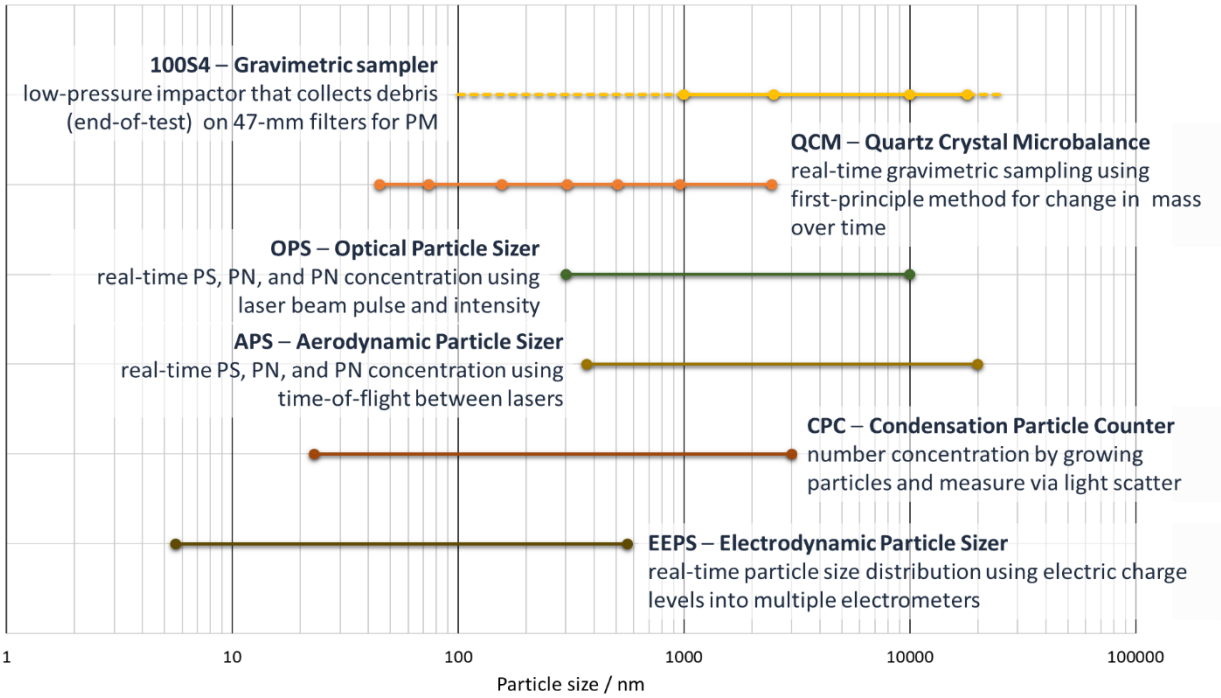
TSI - EEPS™ (5.6 nm to 560 nm)

TSI – CPC (1 to 10 000) #/cm³

TSI – QCM MOUDI™ I140 (0.045 TO 2.5) µm

TSI – APS™ (0.37 to 20) µm

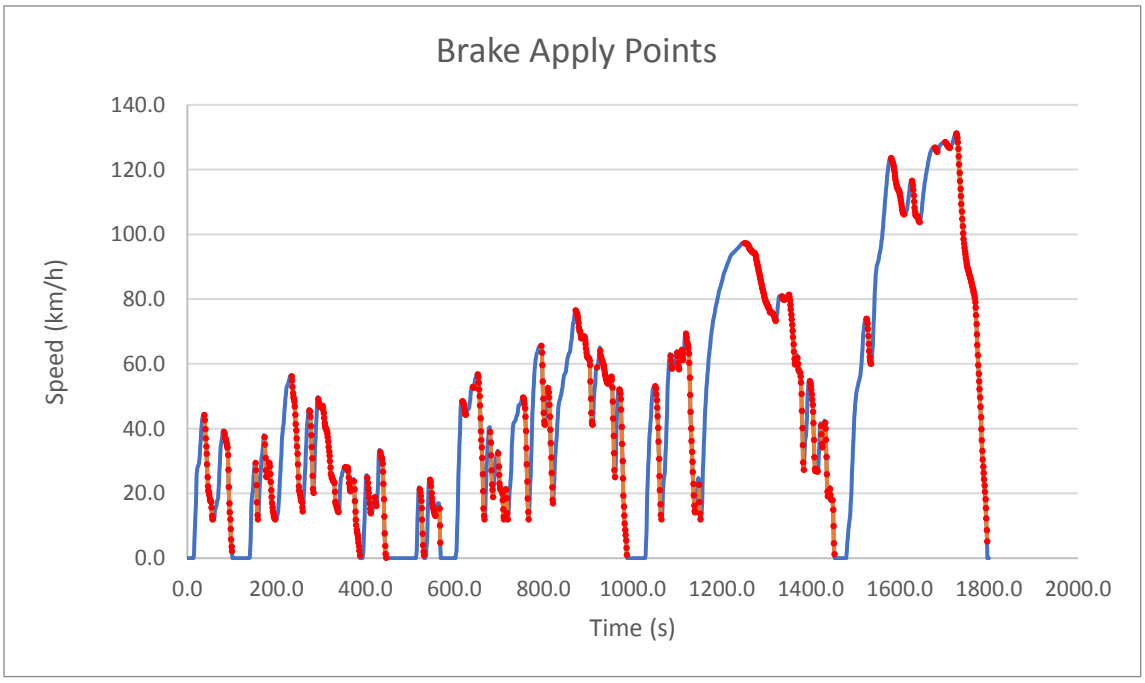
TSI – MOUDI™ 100S4 – (1 to 18) µm



ProLINK Duty Cycle Sim

ProLINK Duty Cycle Sim allows dynamometer testing to simulate a vehicle speed profile, including generally differentiating between when the vehicle slows due to coasting versus when deceleration is associated with vehicle braking. To accurately simulate vehicle coasting, deceleration is accomplished using the dynamometer motor instead of initiating a brake event. Vehicle braking is simulated when the vehicle speed profile deceleration is greater than the deceleration expected if the vehicle were coasting. Note, however, both braking and the natural increase in deceleration when going up a hill are interpreted by the software as vehicle braking.

Duty cycle segments can also be mixed with other test procedure sections. For example, a test segment of hard braking can follow or proceed a duty cycle segment within a single test, greatly increasing testing versatility and allowing for dynamometer testing protocols that more closely simulate vehicle road testing.



Example speed profile; braking segments shown as red dots

ProLINK Duty Cycle Sim Software System Requirements	
ProLINK Software	Version 3.22 or later
ProLINK Dyno Class Scripts	Version 2.09 or later