FTIR SPECTROSCOPY - RUBBER COMPOUND QUALITY CONTROL

The mechanical properties and performance of rubber components are strongly influenced by the rubber compound formulation and its chemical composition. Even where dimensions, hardness, and stiffness remain within specification, variations in polymer formulation, plasticiser content, and additive/curative systems can all influence dynamic behavior, damping characteristics, ageing resistance, and ultimately the performance and service life of a rubber component.

To support AV Industrial Products Ltd quality assurance activities, we operate FTIR (Fourier Transform Infrared) spectroscopy systems, as part of our in-house quality control laboratory facilities, for the control of rubber compound formulations. This provides a powerful method allowing verification of material chemistry and formulation, ensuring consistency of rubber formulation from batch to batch.

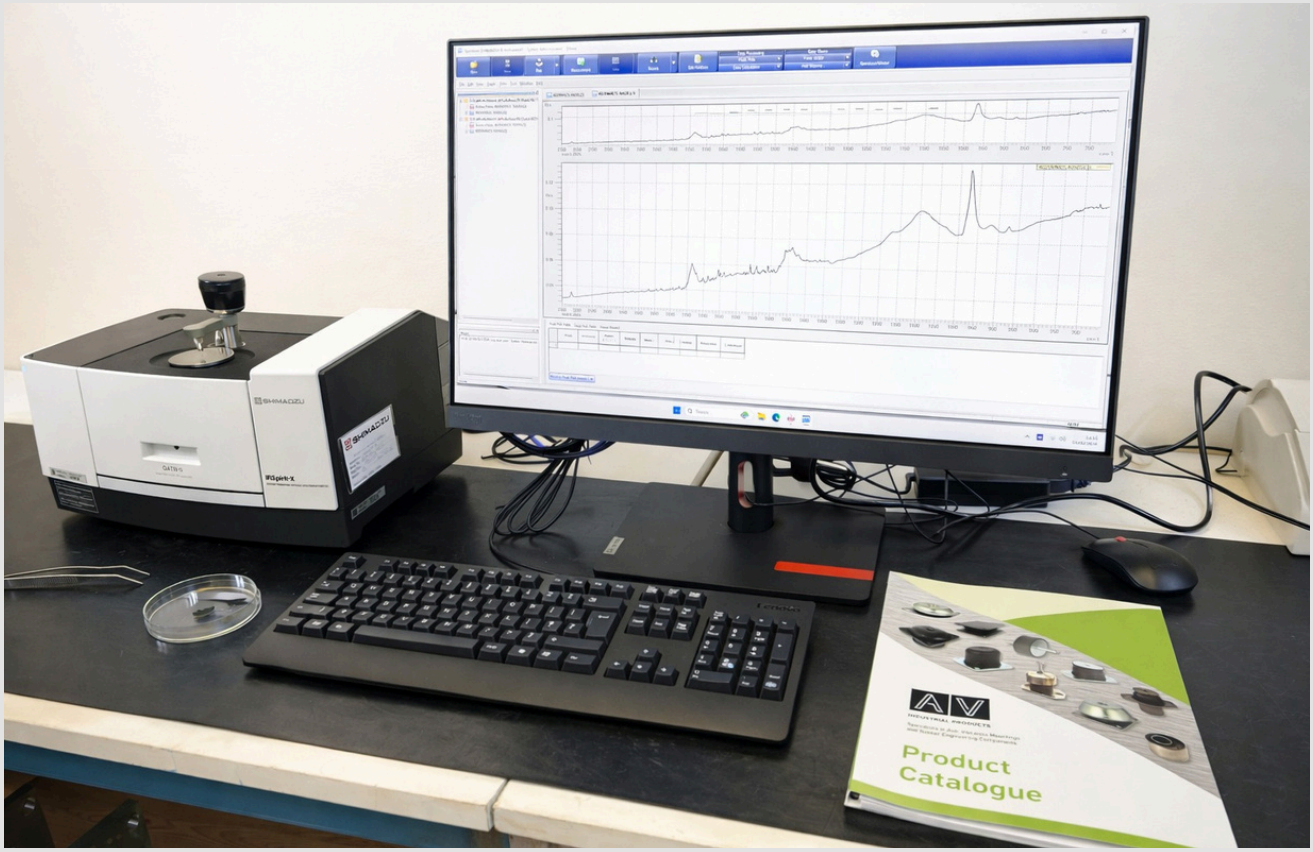

FIGURE 1: FTIR INSTRUMENT USED FOR IN-HOUSE RUBBER COMPONENT ANALYSIS.

FTIR spectroscopy is a scientific test method of measuring the absorption of infrared radiation by molecular bonds within a material, in this case rubber. Different chemical structures absorb energy at characteristic wavelengths, producing a spectrum that represents a chemical fingerprint of the rubber formulation. The output is typically plotted as absorbance or transmittance versus wavenumber (cm^{-1}) across the mid-infrared region (typically 4000–400 cm^{-1}).

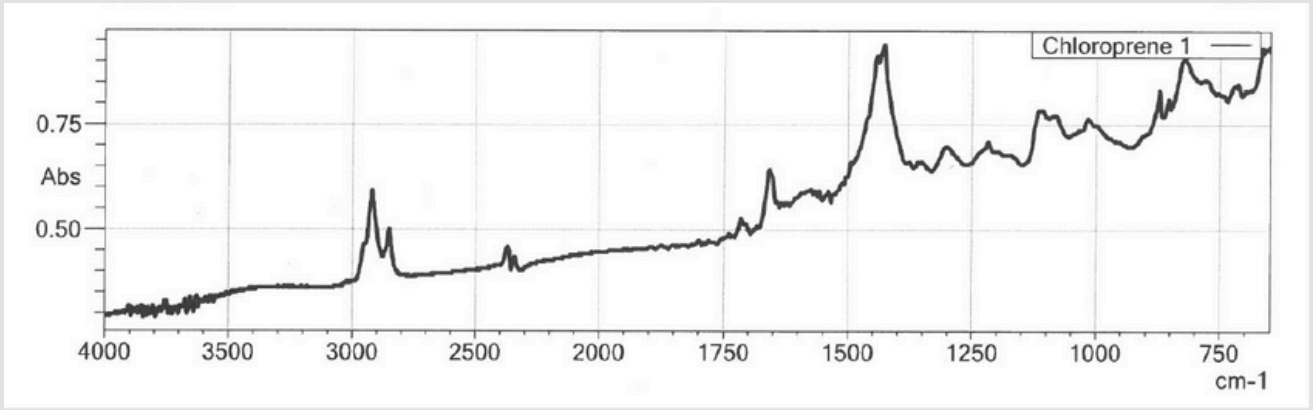

FIGURE 2: EXAMPLE FTIR SPECTRUM OF A FINISHED RUBBER COMPONENT

In elastomeric materials, FTIR can be used to characterize the polymer family (for example Natural Rubber), identify key functional groups associated with additives and oils, and compare materials for chemical similarity or variation, and ultimately create a chemical fingerprint of a rubber formulation.

INTERPRETING FTIR SPECTRA FOR RUBBER COMPONENTS

Different elastomer families exhibit characteristic absorption features, for example aromatic bands associated with styrenic materials, nitrile absorption bands around ~2230 cm^{-1}, and saturated hydrocarbon backbones typical of EPDM-type materials. These features can be used to confirm that components align with the expected polymer class.

Plasticisers and processing oils also provide identifiable absorption bands in the FTIR spectrum. Changes in peak intensity, shape, or relative ratios may indicate differences in oil type, additive systems, or formulation balance, all of which can influence dynamic behaviour and long-term performance.

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FTIR Reference Guide for Common Rubber Polymers & Ingredients

(Typical ATR-FTIR absorbance bands – approximate values)

1. Base Rubber Polymers

Rubber Type	Key Functional Groups	Typical FTIR Peaks (cm^{-1})	What It Tells You
NR (Natural Rubber – cis-1.4 polyisoprene)	C=C, =C–H	1660–1640 (C=C stretch) 840–830 (cis-1.4 out-of-plane)	Confirms natural rubber backbone and cis-structure
CR (Chloroprene rubber / Neoprene)	C–Cl, C=C	830–800 (C=Cl stretch) 1660–1650 (C=C)	Presence of chlorine clearly distinguises CR
	–C≡N (nitrile)	2240–2230 (nitrile stretch)	Nitrile peak intensity correlates with AC
NBR (Nitrile Rubber)	–C≡N (nitrile)	2920–2850 (C=C)	Lack of unsaturation helps confirm EPDM
EPDM	Saturated C–H, alkyl	2920–2850 (C–H stretch 1460–1375 (CH_2 / CH_3 bend)	

2. Typical Rubber Compounding Ingredients

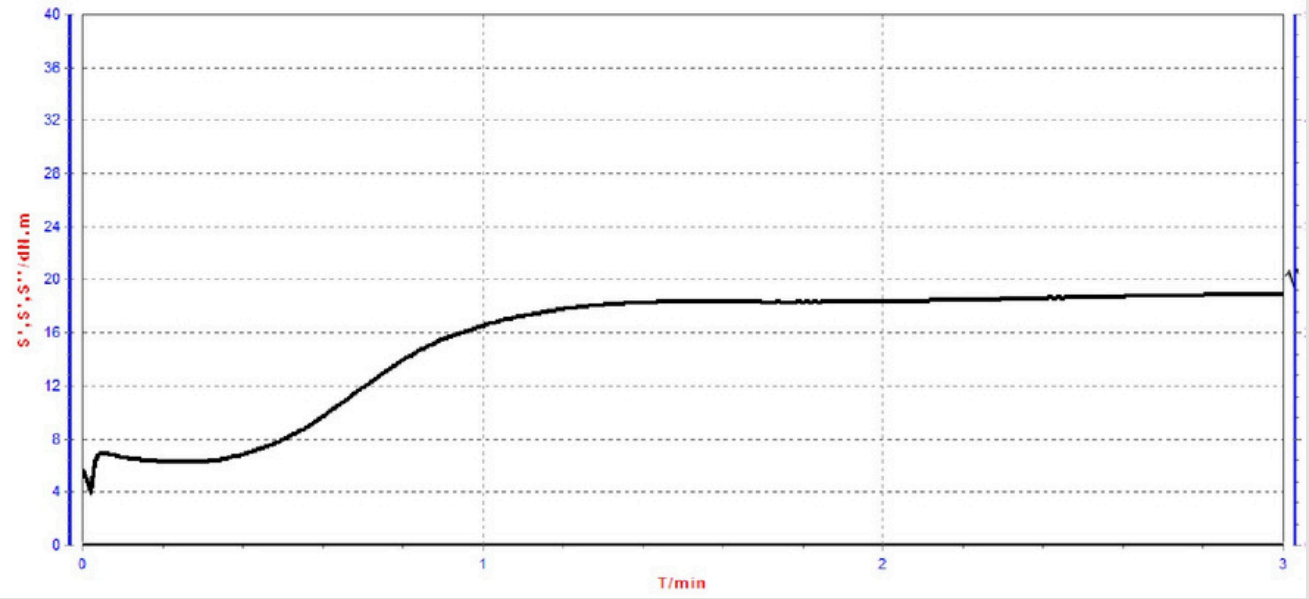
Ingredient	Key FTIR Peaks (cm^{-1})	Notes
Process Oils (Paraffinic/Naphthenic)	2920–2850 (C–H stretch) 1460–1375 (CH_2 / CH_3 bend)	Overlaps with polymer - best seen by comparison Dsingiiusiable from paraffinic oils
Aromatic Oils	1600 (aromatic C=C)	Distinguishable from paraffinic oils
Waxes (Paraffin / Microcrystalline)	2915–2848 (C–H stretch) 1470 / 720 (long-chain	Strong crystalline CH_2 rocking at ~720 (ronutt)
Sulphur (elemental)	*Weak / often not detected	Typically inferred indirectly – Typically inferred indirectly
Accelerators (SS-CBS, MDTS)	1540–1500 (C–N)	Often low concentration – comparison method
Carbon Black	No IR peaks	Detected indirectly via baseline distortion ⊱se IR peaks

FIGURE 3: REFERENCE TABLE FOR KEY CHARACTERISTICS OF RUBBER TYPES

A common application of FTIR is comparative spectral analysis, where spectra from components are compared against reference samples such as a customer approved pre-production sample. Overlaying spectra is utilized to control rubber formulation from batch to batch to ensure consistency, ensure that new or missing absorption bands are not demonstrated, measure relative intensity changes, and measure any subtle shifts indicative of formulation variation.

INTEGRATION WITH BROADER QUALITY CONTROLS

FTIR analysis is used as part of our wider quality and engineering processes at AV Industrial Products Ltd, and is applied selectively based on technical requirements, application criticality, and risk assessment. It complements numerous other in-house testing facilities such as mechanical testing of static and dynamic stiffness, bond testing, hysteresis (energy absorption), permanent set/creep, temperature ageing, as well as dimension inspection and engineering review.



In addition to component-level verification, rubber compounds may be subject to rheometer analysis prior to moulding as part of the manufacturing quality control process, where required. Rheometer testing evaluates cure characteristics such as scorch time, optimum cure time, and torque development, helping to confirm compound processing behaviour before components are produced. This upstream control, combined with downstream FTIR analysis, allows for total material consistency control.

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BENEFITS FOR CUSTOMERS

Our “Quality First” emphasis ensures that products meet our stringent quality requirements without compromising on the application requirements. Our ongoing investment in testing and laboratory facilities, such as FTIR capability allows us to control rubber formulations and compound consistency, support technical evaluations with objective chemical data, investigate material-related questions efficiently, and provide assurance of consistency for demanding and long-life applications.

Quality control is most effective when tools are applied intelligently rather than indiscriminately. FTIR spectroscopy is part of our ‘toolbox’ of testing and laboratory equipment, giving us the ability to examine the chemistry of rubber components, supporting informed technical decisions and ensuring consistent supply.

- In House Measurement & Control of Rubber Compounds
- Assure Consistency batch to batch
- Referenced and Controlled against approved samples
- Research & Development (Reverse Engineering)

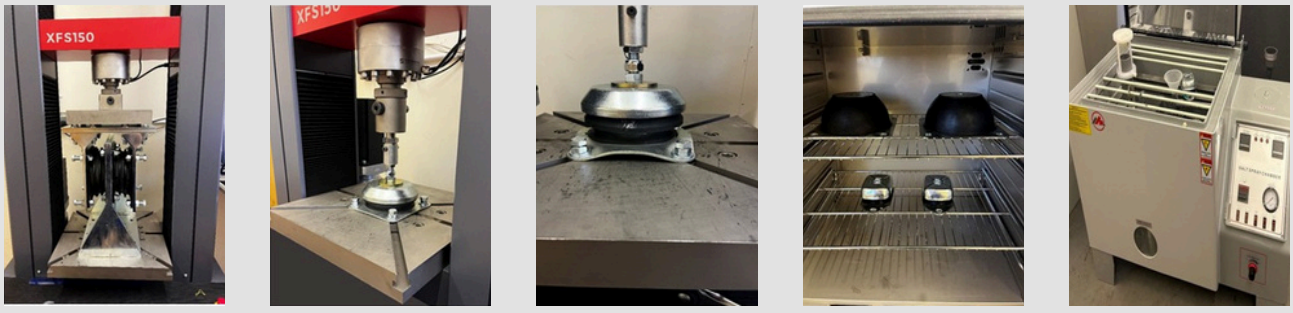

FIGURE 5: FURTHER TESTING & QUALITY CONTROL FACILITIES

Disclaimer
FTIR analysis is one of several quality tools available at AV Industrial Products Ltd, and is applied selectively based on product type, application, and technical requirements. The presence of FTIR capability does not imply universal testing of all products or batches, nor does it replace agreed specifications, certifications, or functional testing unless explicitly stated in writing.

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