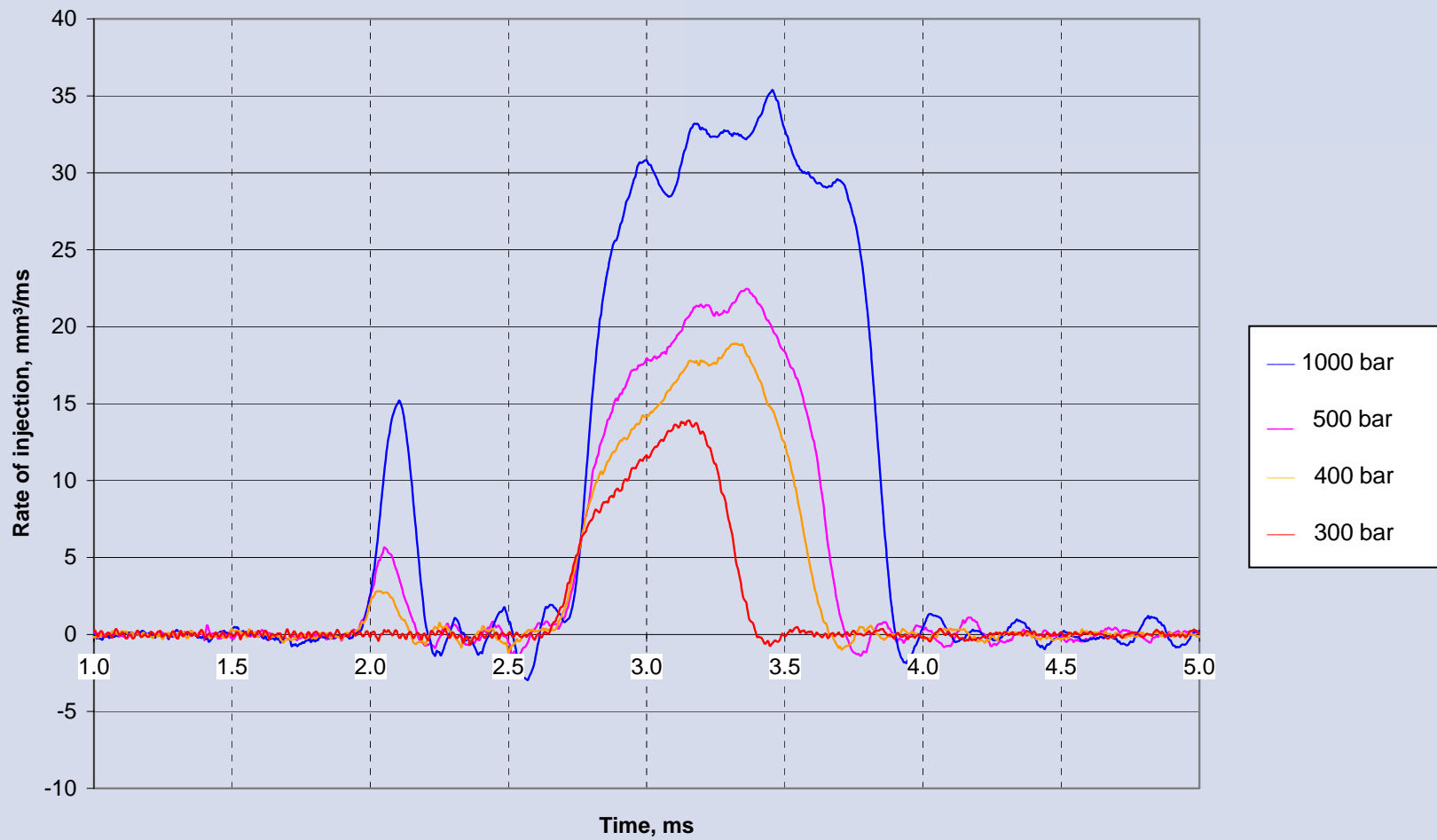




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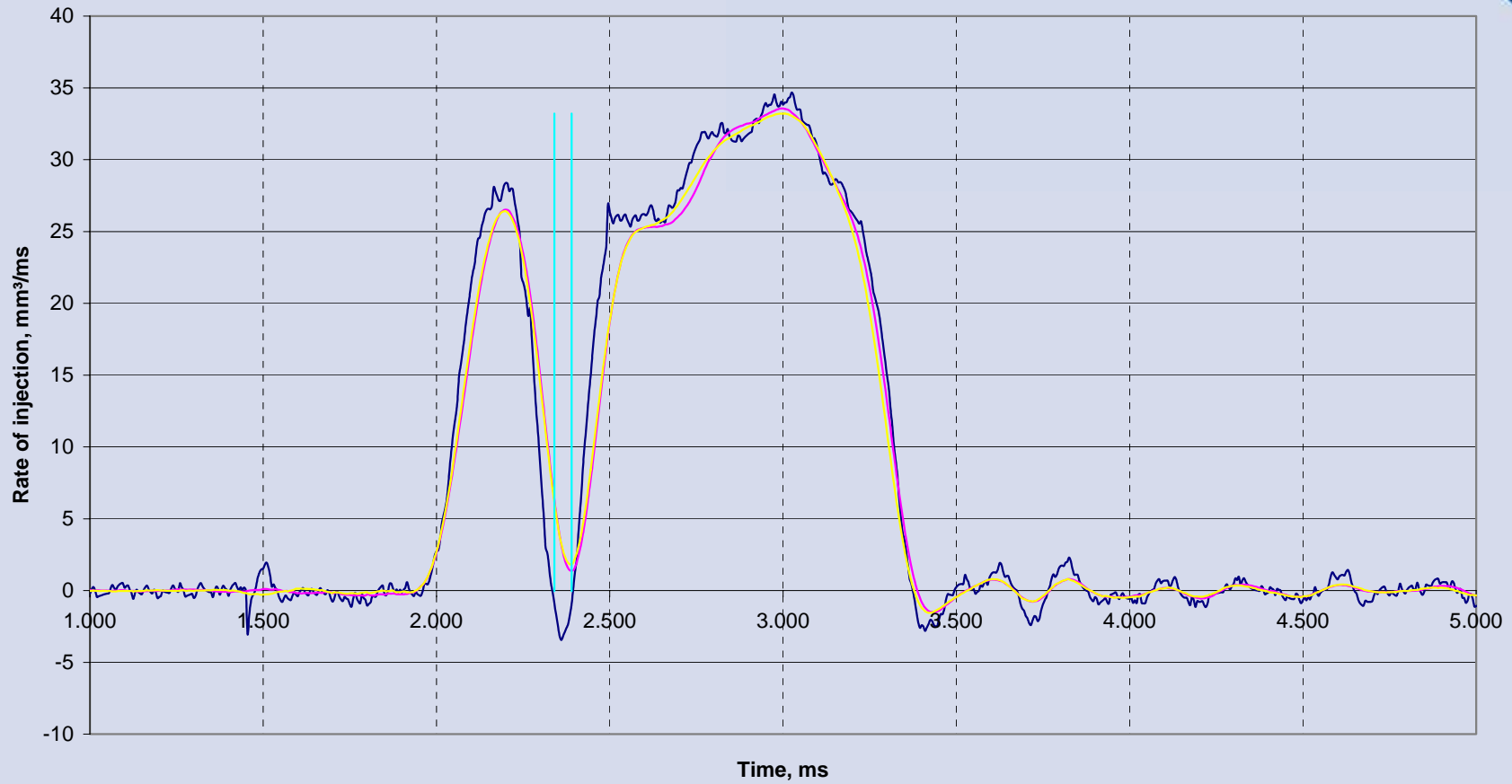
**The influence of
injector characteristics
on emissions**

2 event injection at different pressures showing delivery varying between pilot and main

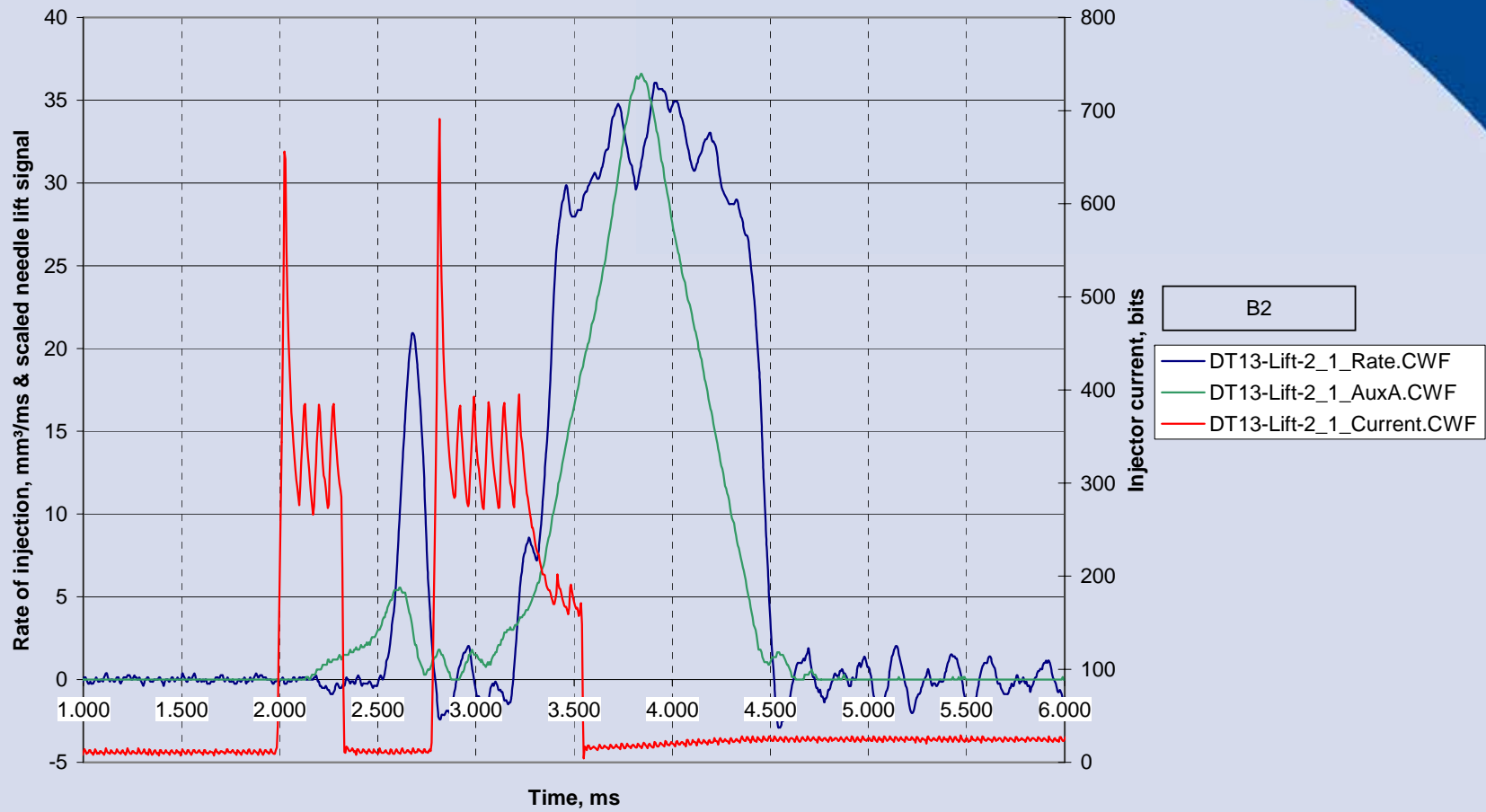


2 close injection events with successfully measured delivery

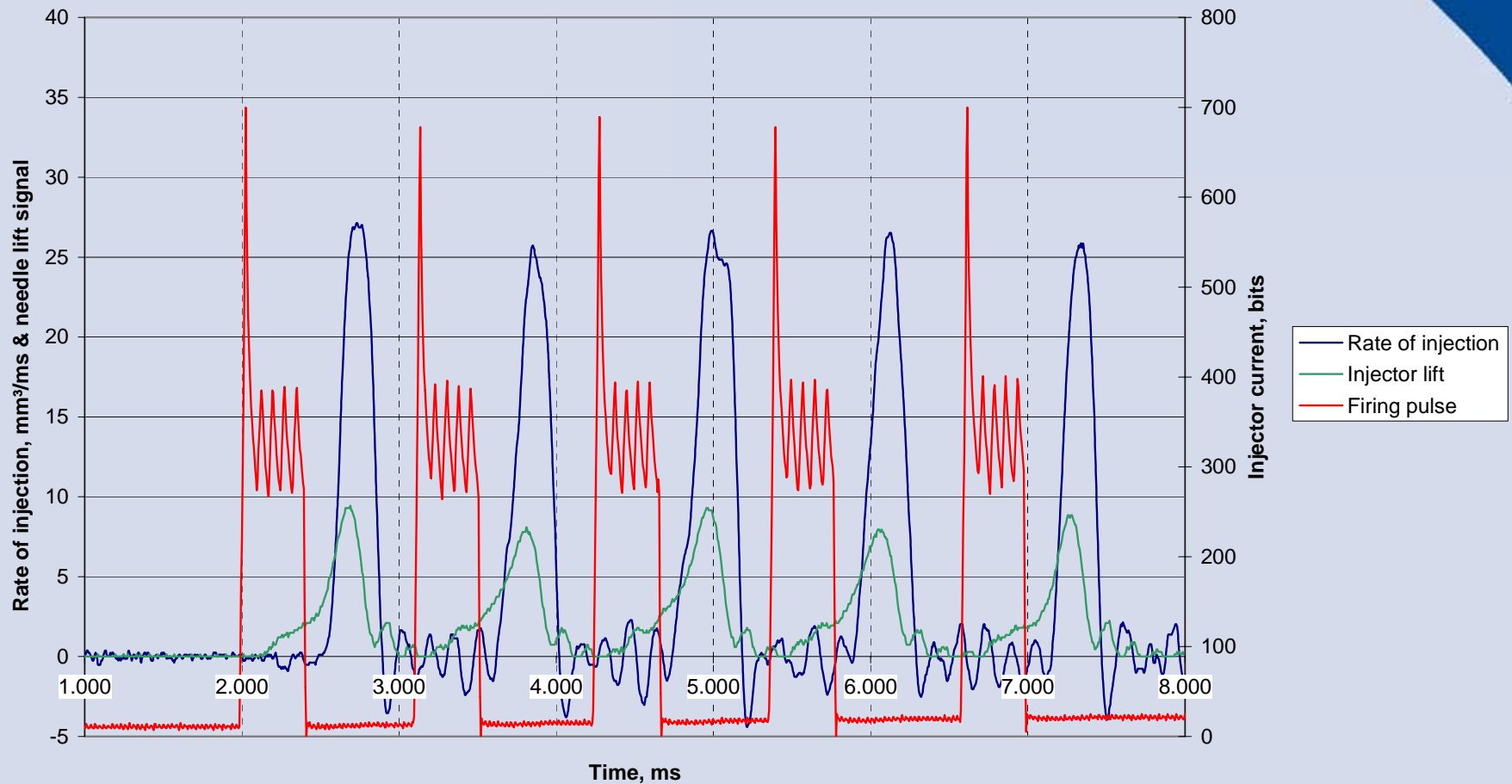
Tram lines indicate
50 μ s separation



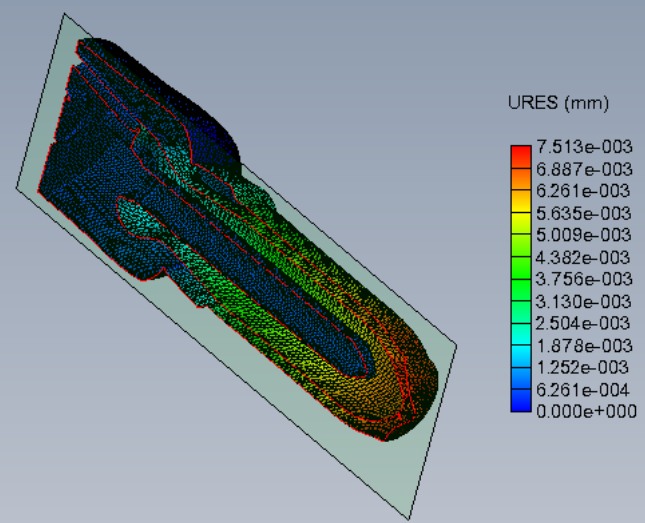
Test point showing rate of injection, injector current and needle lift



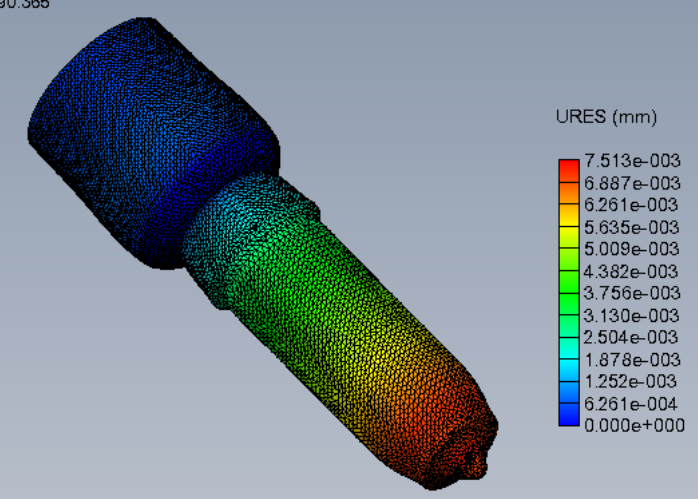
Rate of injection, firing pulse and injector lift for a 5-event injection at 1000 bar



Model name: nozzle1_0.125_LIFT_MODEL
Study name: COSMOSXpressStudy
Plot type: Static displacement Plot2 (-Res disp-)
Deformation scale: 590.365



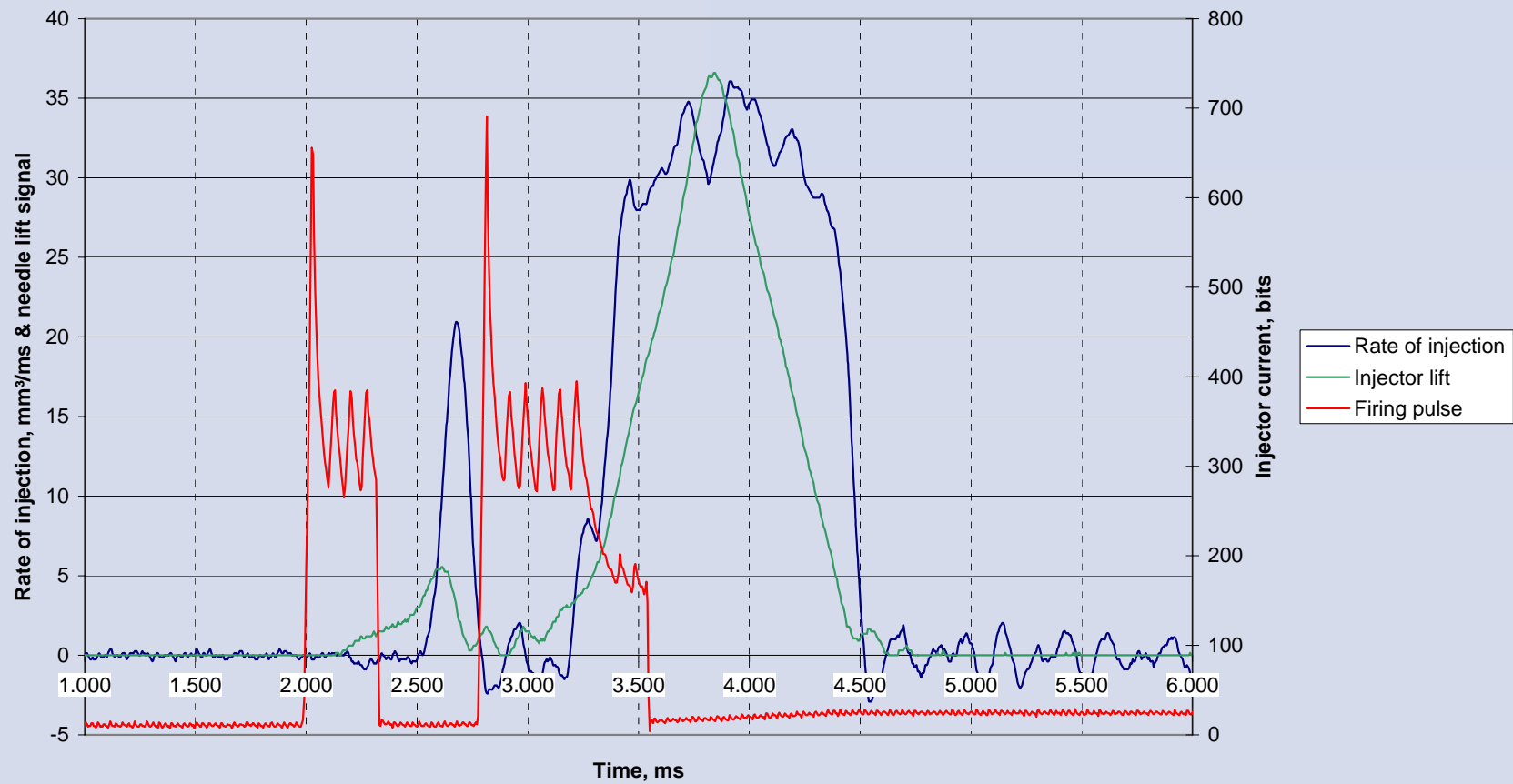
Model name: nozzle1_0.125_LIFT_MODEL
Study name: COSMOSXpressStudy
Plot type: Static displacement Plot2 (-Res disp-)
Deformation scale: 590.365



Physical Properties

| Property | Units | Material | Material |
|----------------------|-------------------|---|--|
| | | "ALLOY STEEL" (DIN - 18 CrNi 8 - 1.5920) | "SILICON CARBIDE - SINTERED ALPHA" (SiC) |
| Young's Modulus E | N/mm ² | 210,000 | 410,000 |
| Poisson's Ratio | | 0.28 | 0.22 |
| Shear Modulus G | N/mm ² | 79,000 | 165,000 |
| Thermal Expansion | | 1.3e- 005 | 1.1e- 006 |
| Density | g/mm ³ | 0.0077 | 0.00315 |
| Thermal Conductivity | W/M degK | 50 | 125 |
| Specific Heat | J/Kg degK | 460 | |
| Tensile Strength | N/mm ² | 723.826 | 600 (250) |
| Yield Strength | N/mm ² | 620.422 | 410 (171) |
| Shear Strength | N/mm ² | 160 | |

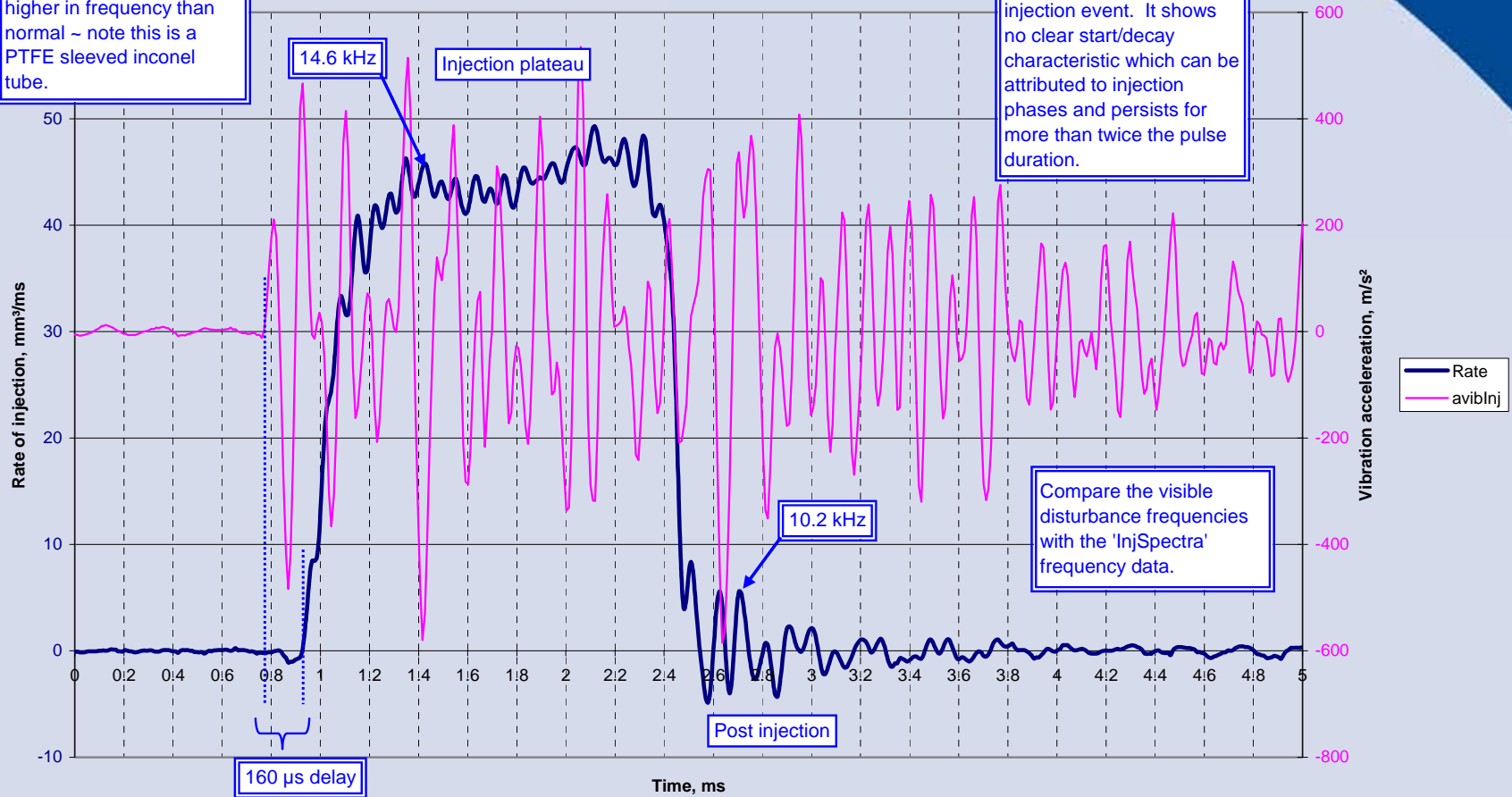
Rate of injection, firing pulse and injector lift for a 2-event injection at 1000 bar



Frequency analyser logged data for an injection event

1000 bar injection event, 1.2ms pulse width. Rate signal disturbance a little higher in frequency than normal ~ note this is a PTFE sleeved inconel tube.

Vibration is induced by the injection event. It shows no clear start/decay characteristic which can be attributed to injection phases and persists for more than twice the pulse duration.



Compare the visible disturbance frequencies with the 'InjSpectra' frequency data.

Renewable fuels vs Fossil fuels

AKRIBIS:

- Typical volumetric accuracies down to 0.05mm^3 are achieved
- Measurements of injection event timing with an accuracy of 20 microseconds are achieved
- Frequency response of 10kHz



An example of a 20 micron hole in a hard ceramic

Length to diameter ratio of orifices can control fuel conditioning

Chemical Composition

| Component | | Material "ALLOY STEEL" (DIN - 18 CrNi 8 - 1.5920) | Material "SILICON CARBIDE - SINTERED ALPHA" (SiC) |
|-----------------|---------------------|---|--|
| Aluminium | (Al) | - | 0.02% |
| Carbon | (C.) | 0.15 to 0.2% | 0.42% (free) |
| Chromium | (Cr) | 1.8 to 2.1% | |
| Iron | (Fe) | remaining % | 0.02% |
| Lead | (Pb) | - | |
| Manganese | (Mn) | 0.4 to 0.6% | |
| Molybdenum | (Mo) | 0.3 to 0.5% | |
| Nickel | (Ni) | 1.8 to 2.2% | |
| Phosphorous | (P) | 0.035% max | |
| Silicon | (Si) | 0.15 to 0.4% | |
| Silicon Carbide | (SiC) | - | 98.90% |
| Silicon Dioxide | (SiO ₂) | - | 0.62% |
| Sodium | (So) | 0.035% max | |
| Vanadium | (V) | - | |

An example of a hardened ceramic nozzle with multiple small orifices

Hardened ceramic nozzle: K factor approaches unity

Ceramic nozzle with possibility of curved orifice pathways to produce helical droplet patterns



INOV8 Engine Test:

- **Managing fuel system analysis results to real performance/emission data**



The influence of injector characteristics on emissions