Experiment Number 17

What effect do DLC coatings have on a simply lubricated contact, in reciprocating sliding?

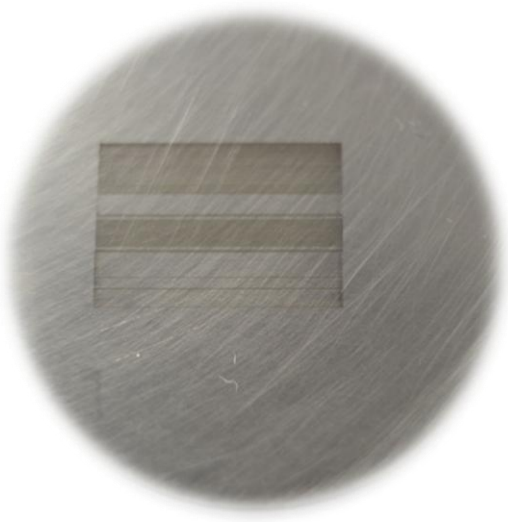
Test Conditions

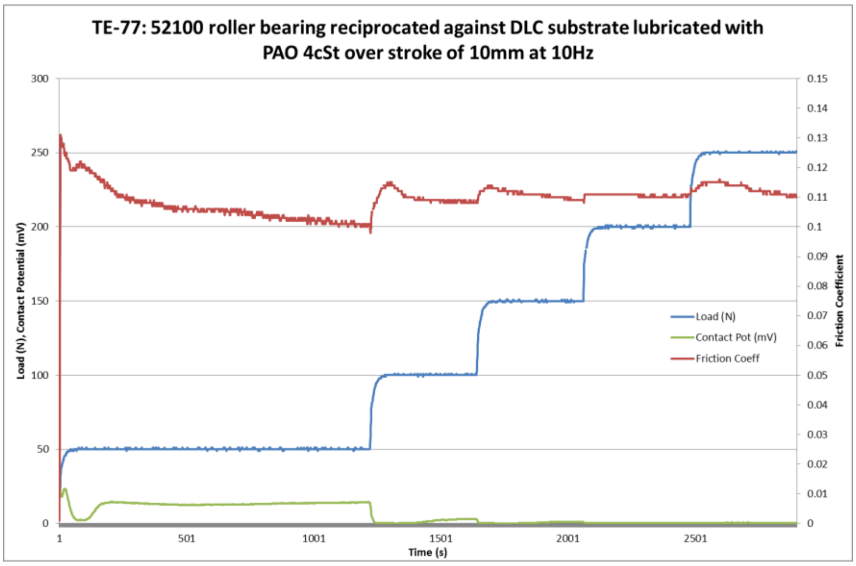
Stroke:	~12 mm	
Frequency:	10 Hz	
Moving Specimen:	6 mm diameter x 10 mm wide line contact	
	52100 steel bearing roller	
Fixed Specimen:	Steel Substrate	
	DLC-TR PVD	(nominally good)
	DLC-IBAD	(nominally bad)
Lubricant:	PAO (4 cSt at 100^{o}C)	
Temperature:	25^{o}C	
Load:	Ramped from 50 N to 250 N in 50 N steps	
Mean Contact Pressure:	Substrate:	Ramped from 190MPa to 430MPa
	DLC Samples:	Ramped from 250MPa to 560MPa
Duration:	50 minutes	
Data:	Load	
	Friction	
	Contact Potential	

Summary of Results

- DLC-TR PVD has a higher friction coefficient compared to IBAD.
- DLC-TR PVD has a lower wear rate than IBAD.
- DLC-TR PVD has a velocity independent friction response compared with IBAD, which has a velocity dependent response.

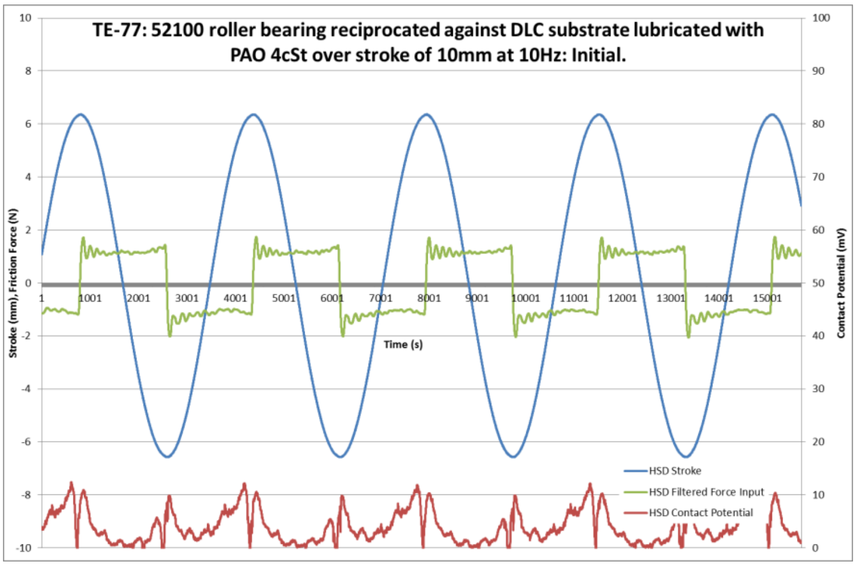
Steel Substrate

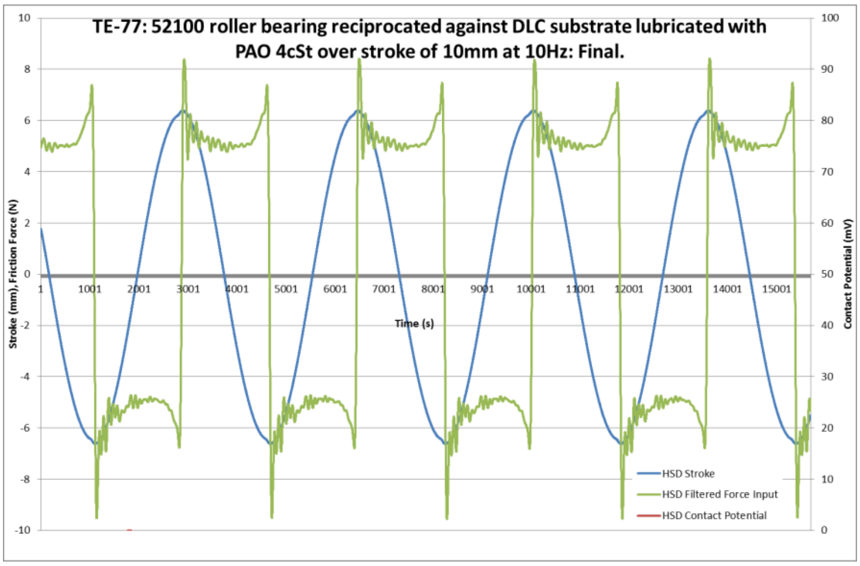




Low Speed Data

- Low speed friction and contact potential traces indicate running-in followed by stabilisation of friction with progressive adhesive wear.
- Load steps initiate further running processes.
- The contact potential drops to almost zero after the load increase to 100N, however towards the end of this step, after run-in has occurred and the friction force has stabilised, the contact potential increases slightly. This is thought to be due to the reduced number of asperities contacting after the running in process.
- Mean friction coefficient approximately 0.1.

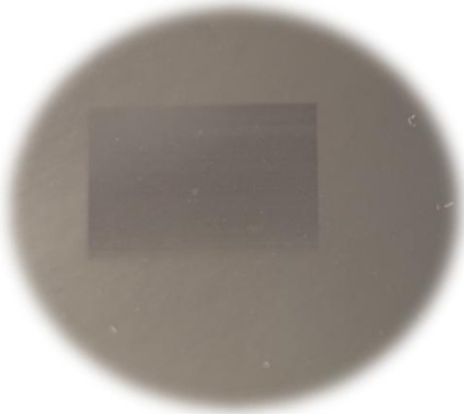


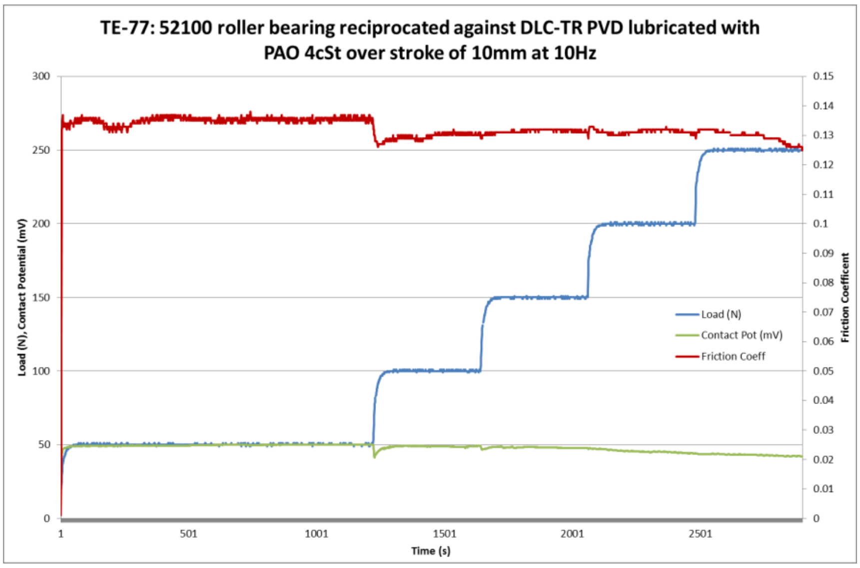


High Speed Data

- “Plucking” resonance of the stationary sample assembly can be seen at the leading edge on each of the square friction waves.
- The contact potential takes a form that would suggest a squeeze film effect is present.
- At the end of the test a 250N load on the contact is sufficient for full metal-metal contact throughout the stroke.
- The square friction wave developed a spike at both the leading and trailing edge of each stroke.

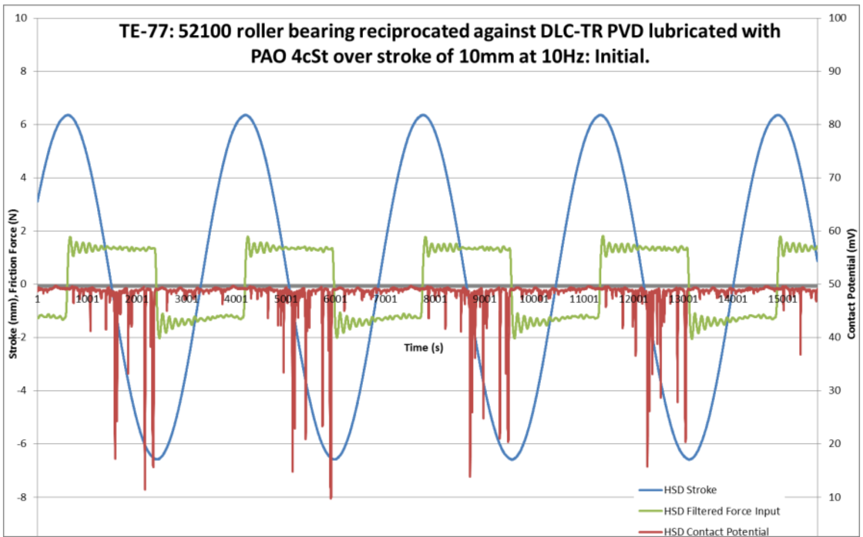
DLC-TR PVD - (nominally good)

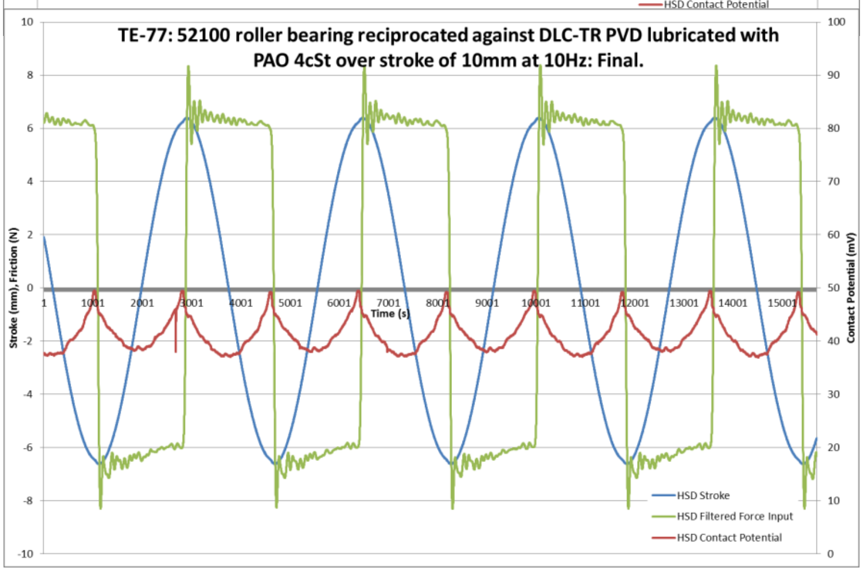




Low Speed Data

- Consistently high electrical contact potential with a slow progressive reduction towards the end of the test, indicating a small increase in metal to DLC contact.
- Low speed friction coefficient stable and not significantly disturbed by load steps, suggesting that little or no running in occurs.
- Mean friction coefficient approximately 0.13, which is the highest for this series of experiments.

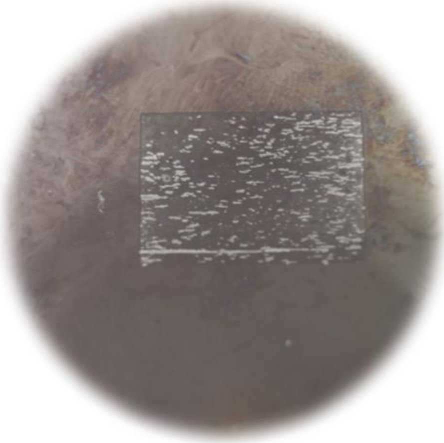


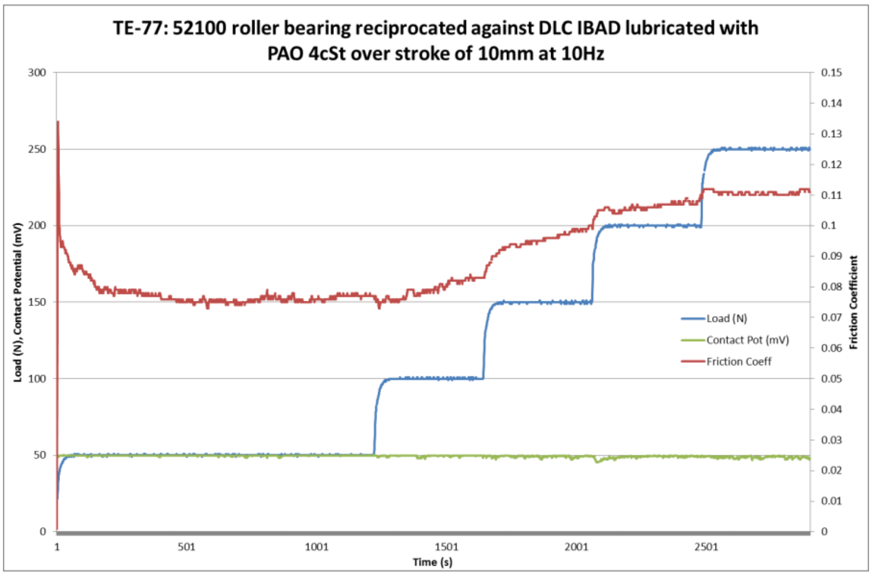


High Speed Data

- Similar to the substrate test, the friction force produces a square wave with evidence of assembly resonance, showing that friction is substantially independent of sliding velocity. At the start of the test there are instantaneous reductions in the contact potential over the stroke; it is not clear what causes this, however the signal was observed to “clean up” a few minutes into the step. This phenomenon was noticed at the beginning of each step, however it appears to have no direct effect on the friction coefficient.
- At the end of the test a friction spike had occurred only at the leading edge of the friction signal.
- The contact potential showed a parabolic profile with a minimum at the mid stroke. This is the opposite of what would be expected, if a velocity entrained film was responsible. Currently no explanation is available other than the possible development of a velocity dependent conducting DLC tribo-layer.
- There is no obvious surface damage on fixed specimen, just slight polishing.

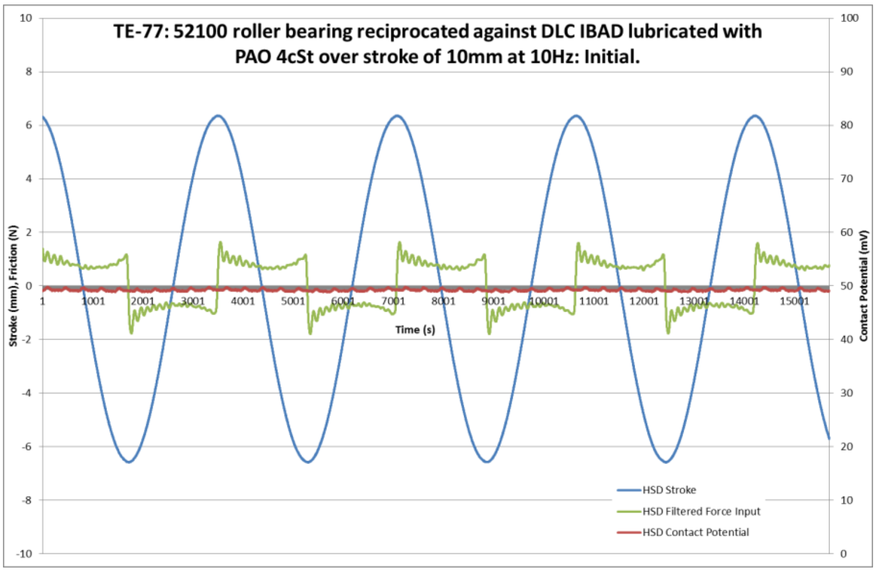
DLC-IBAD - (nominally bad)

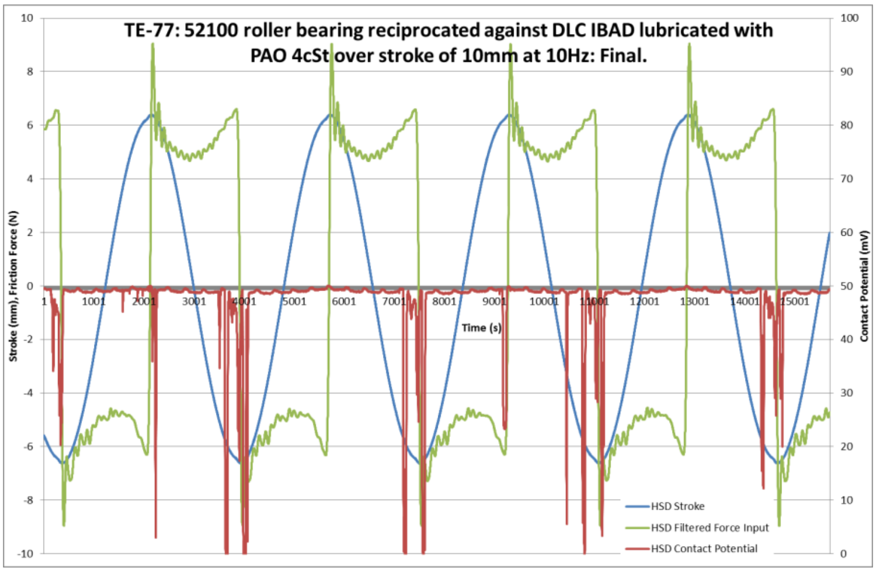




Low Speed Data

- An initial peak in friction at the start of the test is followed by a progressively reducing friction coefficient that results in a steady friction coefficient of 0.075. Each load step caused an increase in friction coefficient, rising to a final value of 0.11 during the 250N step.





High Speed Data

- At the start of the test the friction force shows a velocity dependant profile. It is thought that the reason for the reduction in friction at mid-stroke is because of enhanced lubricant entrainment, at higher speeds. This effect was noticed in the substrate test. It is thought that IBAD, which has a highly polished appearance, is very smooth to start with, thus asperity contact does not disrupt this velocity dependent effect on friction force.
- At the end of the test the friction force has a similar profile but there is evidence of metal to metal contact at the reversal points. The friction spikes are very large, up to 9N, however the majority of the parabola is between 6 and 5N. It has been suggested that the form of the friction trace was caused by third bodies rolling the contact. DLC wear debris was seen on the cylinder, at the end of the test, supporting this hypothesis. However, in the case of the friction modifier, the same form was observed, but at a lower magnitude and in this test no wear debris was found on the cylinder, suggesting that something else caused the observed friction force profile.