WEAR NEWS

Volume 9, Number 4 **Spring 2012**

Gordon Research Conference (GRC) on Tribology

The biannual GRC on tribology was held from July 9 to15 at Colby College, Maine, USA. These conferences are intended to promote informal discussion by researchers on the latest trends in research and to resolve critical issues amongst themselves. The format is: a few invited speakers in the morning; the afternoons are free, and there are a few invited speakers in the evening. In all, 21 papers were invited and all were presented by senior researchers in their respective areas of expertise.

About 115 people attended from nine countries. The US had the largest representation followed by Germany. About 40 attendees were graduate students, about 30 attendees were physicists, about 20 were chemists, and the remainder were from material or mechanical engineering disciplines. There were only six attendees from industry. Most participants were academicians or they worked for a government institute. There were no attendees from China, India, or other Asian countries.

The conference was chaired by Professor Alfons Fischer from the University of Duisburg-Essen in Germany. The conference theme was "Paths of Dissipation" and Alfons assigned topics to the invited speakers. The conference sessions had the following titles:

Extreme Environments
Computer Simulations
Lubrication
Friction and Wear
Tribocorrosion
Tribomaterials
Nanoscale Friction and Wear

There were two poster sessions with probably 30 posters at each. Most talks and posters dealt with science rather than engineering issues.

A unique feature of the Gordon conferences is the significant student participation. The next GRC tribology conference will be preceded by a two-day student-run conference. The students will select a paper from their conference for presentation to their "elders" at the formal conference. The next GRC conference on tribology will be held in 2014 and it will be chaired by Professor Robert Carpick of the University of Pennsylvania.

Solid Particle and Liquid Droplet Erosion: Testing, Modeling, and Applications

This conference was sponsored by the Electric Power Research Institute (EPRI) and their counterpart in Italy: RSE. The conference was held on June 19 and 20 in Milan, Italy. It was attended by about 45 people from 11 countries and 23 papers were presented. The papers were in five areas:

1. Solid Particle Erosion (SPE) – Historical perspective and characterization

2. SPE – Testing and Standardization issues

3. Liquid Droplet erosion (LDE) – Test methods and erosion mechanisms

4. LDE Modeling

5. Protective Coatings – Verification and Field Tests

EPRI's overall objective appeared to be a testing standard (ASTM) on an elevated temperature solid particle erosion test. The following were invited presentations:

- Keynote – Solid Particle Erosion Characterization of Materials for Power Generation – Frederico Cernushi (our RSE host in Milan)
- A Study Comparing the Erosivity of Volcanic Ash and Silica – John Nichols (Cranfield University -UK)
- Use of the ASTM G 76 Solid Particle Erosion Test for Screening Engineering Materials – Ken Budinski (Bud Labs, USA)
- Particle Velocity Measurements – Cliff Weissman (Dantec, USA)
- Overview of Liquid Droplet and Solid Particle Erosion Testing Illustrated by Design, Installation, and Validation of WDE (wet droplet erosion) Test System at NPL – Mark Gee (National Physical Lab, UK)

All papers dealt with either liquid droplet or solid particle erosion. The following is an attempt to summarize what is happening in these two areas:

SPE – The attendees who worked in this area seem to be aircraft and power generation people and the coating people who coat their parts. The jet engine people (GE, Rolls Royce, Pratt Whitney, etc.) are interested in SPE because their engines ingest airborne particles and can be severely damaged if the size and duration is significant (like flying through volcanic ash or landing in a sand storm). The power people (Alstom, GE, Mitsubishi, etc.) seem to worry about oxide (magnetite) spalling from the walls of their steam turbines, particulate fuel (coal), and fly ash. Both groups want protection at elevated temperatures (as high as 800 C).

We heard talks about various hot SPE testers and we had a tour of SRE's facility in Milan. It was a bay full of equipment (20' x 20' x 40') with a dedicated laser velocimeter to measure particle velocity. The rig that impressed me most was the rig in China that was described by Professor Han from Xian Jiaotong University. It has everything but was limited to 300 m/s speed and 600^{o} C operating temperature. A feature that they had that I did not see in other rigs is the use of combustion gas as the fluid to carry particles. This simulates engine conditions better than heated air. Cranfield's rig went to 250 m/s and 850^{o} C; Rolls Royce's rig did 300 m/s and 850^{o} C. The University of Cincinnati has a wind tunnel that can simulate any jet engine speed and temperature (Professor's Tabakoff's rig). One would think that the automobile people would be concerned about dust ingestion on supercharged engines, but big name auto makers were noticeably absent at the conference.

Some SPE rigs used a laser doppler device to measure particle velocity and one paper was presented on how these systems operate. The cost seemed to be in the range of $80 - $120 K. The RSE rig had one.

The SPE people seemed to use a wide variety of abradents. People were well aware that the ASTM G 76 standard test uses 50 µm aluminum oxide. However, the aircraft people seemed to desire particle sizes to 500 µm to simulate what engines encounter (apparently, the volcano ash is large [200 µm]). Everyone seemed to agree that particles below 10 µm in diameter do not produce erosion concerns. Solid particle erosion is initiated by particles cutting and indenting. A 10 µm particle does not produce an indent or cut deep enough to start the fatiguing process. Some models were presented that could predict damage/life effects of SPE.

I presented a paper advocating that a less-aggressive and coatings test procedure be added to the ASTM G 76 test. However, the attendees

seemed more interested in an elevated temperature test than the testing options I proposed.

An ASTM G2 task group meeting was held after the conference to discuss progress on their work item to draft an elevated temperature SPE test or guide. Chairs, Jeff Smith and Swami Swaminathan, reported on progress to date and promised a draft for task group ballot before September 2012.

LDE – The ASTM G 73 test started out being a rain erosion test, but it appeared to me that droplet erosion is a major concern in the power industry because water droplets form in the downstream regions of steam turbines and erode the blades. Water is introduced into gas-fired compressors to lower temperature and the droplets damage these devices. Aircraft ingest droplets when they go through rain fields, and the military are concerned about sea water droplets being ingested into their Harrier-type vertical take off aircraft. It raises the corrosion concerns that salt water always poses.

Nobody at the conference copied the rig described in ASTM G 73, but they all copied the concept – samples on a rotating arm and direct droplets at the rotating specimens. Some used horizontal rotating arms, some used vertical arms. Some use nozzles to make droplets; some used a chopped stream to make droplets. The droplet impact speed seemed to range from 600 m/s in 4 m-diameter steam turbines to as low as 200 m/s in aircraft. There was a lot of discussion on the role of droplet size, but the talks covered droplets from 0.50 to 500 µm. They mostly use high speed photography to measure droplet size and velocity.

Much to my surprise, there were attendees using the ASTM G 32 vibratory horn cavitation test and a version of the ASTM G 134 water jet cavitation test to screen materials and coatings for resistance to water droplet erosion. I formed the opinion that somebody should investigate this correlation before building another million-dollar rotating arm apparatus. The vibrating horn has got to be cheaper and easier to use and it works on the principle of a jet of liquid being produced when a cavitation-induced bubble implodes.

We toured the RSE water droplet erosion rig during our RSE tour. They used a rotating arm about 1 m in diameter with a test specimen on each tip. The arm was affixed to a horizontal drive shaft and the droplets were produced by two spray nozzles aimed at holes in a sealed chamber that was evacuated to reduced pressure. Apparently the "used" droplets need to be removed so that they do not slow or heat the rotating arm. Their rig was duplicated by the company that built it and the owner of the other rig was present at the conference. The basic design of the rig at NPL in the UK was the same (Mark Gee's rig).

Summary

Overall, this was the only conference that I ever encountered on particle and droplet erosion and to me it validates the continued importance of the ASTM G2 erosion standards (G 76, G 73, G 134, G 32). Needless to say, users modify our standard tests to make them suit to their industry, but when they do, they serve as a useful guide. So if people are not using the exact test method, they are guided by it and substitute their abrasive or speed, etc. As a G 76 user, my perceived needs for additional procedures under G 76 were confirmed. I will proceed with a less aggressive option and possibly a coating test option. Jeff Smith and Swami Swaminathan will proceed with a separate elevated temperature erosion test method or guide.

This conference would not have happened without the driving force and guidance of David Gandy from EPRI and the facility and logistical support from Frederico Cernuschi. All of us attendees thank them for creating such a significant technical event. Erosion is often slighted in most tribology conferences and SPE and LDE are really limiting factors in power generation and aviation. It was certainly refreshing to see tribology's dirty little secret, "erosion" given top billing in a conference. Thank you again David and Frederico.

3rd International Symposium on Tribocorrosion

Tribocorrosion is "wear "or "corrosion" that is exacerbated by rubbing contact. The first symposium was held in India; the second was held in Germany and the third was held in Atlanta Georgia at the Georgia Tech University. The symposium was sponsored by the ASTM G2 Committee with Georgia Tech supplying meeting rooms and logistics. About 60 people attended from more than 15 countries. About 40 papers were presented with six keynote speakers. There was also a commercial exhibit and poster session on the fist day of the symposium. There were concurrent sessions so attendees had to select which papers to attend. The following are some general comments the nature of the symposium papers.

Studies Using Polarization Techniques

The papers that I attended that dealt with the electrochemical aspects of tribocorrosion usually used a pin-on-disk test rig with a plastic cup holding the disk counterface and the usual pin rider. The test liquid is put into the cup along with a reference electrode that allowed the corrosion potential of the rubbing couple to be monitored in real time. When the rubbing starts the open circuit potential (OCP) changes and they use this parameter to monitor how much corrosion is playing a role in material removal. There were many different interpretations of the electrochemical responses during rubbing but a net result seemed to be a quantification of the "synergy", the role of corrosion in the material removal process. If the synergy is high, corrosion may be a larger contributor than wear. However, I left the conference not knowing if high synergy is desirable or not. At this point I think that if the synergy is high, more corrosion-resistant materials need to be used. The ASTM G 119 standard on synergy of course would have answers to my questions if I had read it.

Passivity Studies

There were multiple papers that dealt with what happens to metals that derive their corrosion-resistance from passive surface films (like stainless steels). These studies also used potentiodynamic polarization techniques to observe what happens to passive films during rubbing. In Many tribosystems the rubbing of an area is intermittent and the polarization equipment allows investigators the opportunity to study how much of the passive film is removed in a single rub and how much the protective film reforms before the next rub occurs. This seemed to be a useful piece of information for industrial applications.

Erosion

There were multiple papers dealing with tribocorrosion without electrochemical measurements. Some papers discussed the use of solid particle impacts at elevated temperatures; some used the ASTM G75 slurry corrosion test (Miller Number) and the companion SAR (Slurry Abrasion Resistance number. The latter yields a corrosion/wear synergy, but the particle impact tests did not have a standard to determine the synergy between material removal from particle cutting compared to oxidation. Some of the solid particle papers dealt with the mechanism of material removal and how particles can be entrapped or embedded. We saw amazing FIB cross-section images throughout the symposium.

One paper on slurry erosion of pipelines showed Miller numbers and SAR numbers on a wide variety of pipeline materials. Surprisingly, the "best" material overall was a carbon steel with a completely pearlitic microstructure.

Fretting

There were multiple papers on fretting corrosion, but I did not attend any that used electrochemical techniques to explore the "corrosion" component of fretting damage. I attended two papers on the classic fretting that occurs in tube bundles that contain the radioactive fuel in nuclear reactors.

The tubes are usually made from zirconium alloys and the fretting motion occurs from fluid flow effects. Apparently everything jiggles and the tubes touch each other in spots and holes can be "fretted" that release radioactive fluids. I have heard about these problems for decades and I left the conference with the feeling that the problem has not been solved, but is still actively researched.

Other papers on fretting dealt with fretting in water and at elevated temperatures. Our Georgia Tech hosts included their high-temperature fretting rig in a day two tour of selected university facilities. It has a capability of elevated temperature testing and instrumentation that allows generation of friction logs – three dimensional displays of friction force loops versus time.

Erosion by Nanofluids

Several papers dealt with the erosion/slurry effects of adding nanoparticles to liquids. Apparently adding certain nanoparticles to aqueous solutions increases their conductivity and thus their ability to perform heat transfer functions, but does the additive of addition of these particles increase erosion or tribocorrosion in the tribosystem? These were the types of issues addressed.

Bio-tribocorrosion

The symposium had two sessions on tribocorrosion in medical fields. Some papers addressed corrosion of dental implants, others hip implants, others dealing with more general applications of in-vivo use of engineering materials under rubbing conditions. One paper was on the fretting of screws and plates that are used in fixing broken bones. There were at least five papers on tribocorrosion of dental implant materials. Apparently, titanium alloys are widely used, but their "tribonetic" properties are often lacking (Note: I published a paper on the Tribonetic Properties of Titanium alloys" and none of the reviewers objected to the word "tribonetic" which I made up to mean "tribological." I stopped using it and now use the longer and duller "tribological" adjective.)

Overall, it looks like titanium alloys for in-vivo use is a "hot topic" in biotribology and bio-tribocorrosion. Titanium does well in body fluids, but tends to transfer in rubbing contact and to easily abrade. Researchers seem to be competing to find ways to overcome titanium's birth defects: poor rubbing and abrasion resistance.

Tribocorrosion Modeling

There were four keynote speakers at the symposium and for the most part, they discussed what is going on in modeling tribocorrosion systems. Most of the models proposed involved electrochemical corrosion measurements, the kind of things performed with potentostatic and electrochemical impedance devices. As is the situation in all tribology, few models are developed to the point which lab testing is no longer necessary.

Summary

This 3rd international symposium on tribocorrosion was a great success in every metric. The venue was great – two days in Atlanta with great weather and great meeting facilities graciously provided by Georgia Tech. The papers and posters covered most aspects of tribocorrosion and it was easy to pick up usable information. The papers will be published later in and STP publication from ASTM International or in "Tribology" Journal. The international tribology community owes a debt of gratitude to Rich Cowan and the Georgia Tech Manufacturing Research Facility for hosting the symposium and to Dr. Peter Blau of Oak Ridge National Lab for making the symposium happen. Peter had assistance from a steering committee and others, but he was the prime mover. We thank you, Peter.

STLE Annual Meeting:

The Society of Tribologists and Lubrication Engineers (STLE) held their annual meeting from May 5 to 10 in St. Louis, MO, USA. STLE has two meetings a year and this is the larger. There were about 1100 attendees from most lubricant-using countries. There were 350 papers, 10 education courses, student posters, a commercial

exhibit, committee meetings, two parties (welcoming, berries and cream), a luncheon, lots of awards (at the luncheon), and one keynote speaker: Margaret Stack from the University of Strathclyde in the UK. The talks were held in the America Center with concurrent sessions. So a single attendee could only be exposed to about 50 of the 350 that were given. I went to 40 and the following are some topics discussed, my learnings, and new-to-me words heard at the conference.

Paper Topics

FEA modeling
Molecular dynamics modeling
Seals (lip, gas, etc.)
Scanning probe microscopy (AFM, etc.)
Tapping torque
Diesel soot
Oil additives
Chemistry of oils and metal working fluids
Green lubricants*
Lubrication in power generation*
Biotribology (eyes, teeth, hips, knees)*
Ionic liquids
Rolling element bearings*
Oil analysis
Condition monitoring
Elastomers for seals and oil contact
Contact mechanics*
Gears*
Greases*
Synthetic oils
Fluid film bearings*
Emulsifiers
Non-ferrous rolling*
Ceramics/composites*
Surface engineering*
PV
Wear*

*Session topics

New-to-me Words

XANES - X-ray absorption near edge spectroscopy
Ellipsticity – like an ellipse
Stomestic - ? (did not look up)
Precision Electron Diffraction
Etiology - ?
Bespoke (laboratory rig) – means custom
Convoloid (gearing) – new tooth shape
Estolides - ?
Voxel [as in sphere-on voxel (maybe he meant Vauxall car] -?
Inositol - ?
Alkylphosphorofluoridothioates - ?

Learnings

70% of the Chinese population can afford to buy an automobile – Simon Tung

Asperities are still assumed to control everything that slides – Kenneth Budinski

People think that putting nano-things in oil will make them lubricate better – Kenneth Budinski

Putting nonodiamond particles in oil lowers friction, but wears out the rubbing surfaces – C. Novak.

The onset of galling can be detected as a friction force spike – Greg Dalton

Big earth movers use BeCu plain bearings on those huge wheels because rolling elements cannot carry the load – B. Feng

The best natural oils are high-oleic vegetable oils – B. Sharma

You should test plastics on a multi-axis tribotester since direction of motion can play a significant role in tribological properties of the system – C. Swartz

There is a need for a blood pump lubricated by blood – R. Wampler

ZDDP is still the only oil anti-wear additive worth anything and a replacement is still a hot area of research – Kenneth Budinski

Scuffing is the term preferred by lubrication engineers to describe localized macroscopic wear – Kenneth Budinski

The "Reffel test" is the standard test for fretting damage testing of wind turbine parts – R. G. Spagnoli

Friction of rubber vs. other solids is anisotropic; direction to manufactured surface may affect results – Kenneth Budinski

There is a standard test for rolling element bearing materials – F. Gadeghi

The STLE definition of scuffing: – any significant local change in surface texture

A 5% (min) cone bleed is needed for a grease to prevent fretting damage

False brinnelling in automobiles can be simulated by partial rotation of bearings to 50% load capacity with oscillation of plus/minus 3^o at 2 Hz – French research

Overall, this meeting is the place to go to present research results that involve lubricants, machinery fluids, and all kinds of bearings. Wind power papers seemed to be down over previous years and scuffing seemed to be overly popular. Nano talks also seemed modulated. Noticeably absent were papers on erosion and abrasion, but that is to be expected since lubricated systems are the focus.

The venue was very good; the St. Louis weather was quite agreeable, and the STLE organizers did a superb job of running the affair – very professional. I'll try to keep going; next year's is in Detroit about the same time.

ASTM Spring 2012 Meeting:

The spring 2012 meeting of the ASTM G2 committee on Wear and Erosion was held at the Manufacturing Research Center of George Tech University in Atlanta, Georgia, USA before the tribocorrosion symposium. The following are summaries of the activities of the various subcommittees.

Abrasion Activities

The spring 2012 subcommittee was chaired by Scott Hummel (Lafayette College) for Brian Merkle (Nanosteel) who was not in attendance. Ken Budinski (Bud Labs) reported on the ballot status of the ASTM B 611 high-stress abrasion test. Two negatives and six comments were received. The negatives were considered persuasive and the comments addressed a variety of issues in the standard. Ken Budinski will revise the standard accordingly and reballot it.

Jim Miller (Whiterock Engineering) reported that the Miller number/SAR standard G 75 needs reapproval and that he will ballot it as-is for reapproval.

Scott Hummel reported that the other abrasion standards needing reapproval were as follows: G 105 wet abrasion test, G 132 pin-abrasion test, G 81 jaw-crusher abrasion test, and G 145 Taber Abraser test. All will be reballoted without revision.

Troy LeVally (Falex) reported that there are still significant problems with the rubber wheel used in the G 65 dry sand rubber wheel abrasion test. There was a plan to try to replace the chlorobutyl rubber with neoprene, but as it turned out, their chlorobutyl rubber supplier started to supply neoprene to Falex in place of chlorobutyl so some customers may have neoprene wheels when they think they have chlorobutyl wheels. Falex will investigate the situation and inform affected customers.

Scott Hummel reported that his students conducted a study on the dry sand rubber wheel test to determine if the current sand flow range is acceptable. He ran abrasion tests on the same material with sand flows of 50 g above and below the mean of 350 g/min required in the standard. These test showed that the present 350 = 50 g/min is acceptable and does not need to be modified.

Peter Blau (ORNL) proposed a new wet abrasion test: a disk specimen rides on edge on a rotating

wheel (8" dia polishing) wheel with 180 grit SiC bonded abrasive on the wheel. The sliding distance is controlled along with the normal force and wheel rpm. The test metric is wear volume of the rider. Peter will ballot the new standard before the next meeting.

Non-abrasive Wear Activities

The subcommittee meeting was chaired by Scott Hummel and he reported that the G 196 galling test will need review for reapproval. He will do it. Scott also reported in the results of the recent interlaboratory study (ILS) using the G 196 procedure. He measured a high coefficient of variation (as high as 0.76) and that these data will be used to deduce the number of test replicates needed. Scott also reported that the G 98 galling test will be revised to require three replicates at each apparent pressure. He will ballot to have the new version replace the old version of G 98.

Friction Activities

Subcommittee Chair, Ken Budinski (Bud Labs) reported that there were negatives and comments on the recent ballot of the G 115 Guide to Friction Testing appendix. The appendix was intended to supply information on friction observations that would be helpful to users of the guide. Ken reported that support for the appendix was less than lukewarm and it will be withdrawn and replaced with a new non-mandatory information section that addresses the specific issues that need to be addressed in every friction test, such as speed, load, cleanliness, etc.

Ken also reported that he reviewed the rolling element bearing friction test (G 184) for reapproval and found a few definitions that need more attention: need to use G 40 definitions. He will edit the standard and reballot.

Data Acquisition Activities

Scott Hummel chaired the meeting in the absence of Chair Greg Dalton (Tribsys). Scott reported that the G 190 Guide to wear tests needs reapproval. He will contact Ray Bayer for this. It was also suggested at the meeting that the Falex "TAN" number be considered for inclusion. It describes the mode of surface contact.

Terminology Activities

Chair Peter Blau reported that negatives received on "abrasion" and "incubation period" were persuasive and the balloted terms will be withdrawn revised and reballoted.

Miscellany

- Web meetings – The last two G2 committee meetings were conducted with members worldwide joining in by phone conferencing. It has worked well and all members are encouraged to use it when they cannot attend.

- New Activity – A work group is being formed to supply information and review for an "adjunct" that will be proposed on "What wear and erosion look like". Ken Budinski will draft the strawman and Greg Dalton, Scott Hummel, and Troy LeValley will serve on the workgroups.

Future G2 Meetings:

- Fall 2012 – September 20-22, 2012
  Boston, MA

- Spring 2012 – June 26 & 27, 2013
  Montreal, Canada
  (with D2)

- Fall 2013 -- November 4 & 5, 2013
  Philadelphia, PA
  (ASTM Headquarters)

- Spring 2014 – Salt Lake City, NV

- Fall 2014 -- San Diego, CA

Officer Candidates for 2012:

The following have been identified by the nominating committee as candidates for office in 2012:

Chair – Scott Hummel – Lafayette College
Vice Chair – Greg Dalton – Tribsys Company
Secretary – Mike Anderson – Falex Corp.

Tribology Events:

Dr. Peter Blau of Oak Ridge National Labs prepared the appended list of tribology events for the next two years. Thank you, Peter.

NOTE: Wear News is the informal account of selected tribology events and the activities of the ASTM G2 Committee on Wear and Erosion.

Contributed tribology articles and comments are welcome. Send them and other inquiries to:

Ken Budinski
Bud Labs
3145 Dewey Avenue
Rochester, NY 14616 (USA)

Tribology events calendar – Courtesy of ASTM Committee G-2 on Wear and Erosion

Date(s)	Meeting name - Location	Contact	URL/email
		Calendar year 2012	
2 – 4 Apr	1st Faraday Discussion in Tribology – Southampton UK	National Centre for Advanced Tribology, U. of Southampton.	E-mail: events@rsc.org www.rsc.org/events
17 – 18 Apr	ASTM G2 Meeting – Atlanta GA (with Tribo-Corrosion 2012, below)	Contact: Alyson Fick, ASTM Intl, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959; tel. 610-832-9710	E-mail: afick@astm.org http://www.astm.org
19 – 20 Apr	3rd International Symposium on Tribo-Corrosion – Atlanta, GA	Contact: P. Blau, Oak Ridge National Laboratory; Oak Ridge, TN symposium is co-sponsored by ASTM G2	E-mail: blaupj@ornl.gov
23 – 27 Apr	International Conference on Metallurgical Coatings and Thin Films – San Diego CA	Mary S. Gray, Suite 136, 14001-C Saint Germain Drive, Centreville, VA 20121; Tel. 703-266-3287	E-mail: icmctf@mindspring.com
6 – 10 May	STLE Annual Meeting & Exhibition – St. Louis, MO	Society of Tribologists and Lubrication Engineers, 840 Busse Highway,Park Ridge, IL 60068-2376; Tel (847) 825-5536	www.stle.org
20 – 24 May	2012 New Diamond and Nanocarbons Conf. – San Juan, Puerto Rico	Materials Research Society (one of the sessions is on Carbon-based coatings for tribological applications)	www.mrs.org/ndnc-2012
4 – 8 June	5th Meeting: International Research Group on Tribology in Manufacturing – Notre Dame, IN	Steven R. Schmid, Ph.D., Depart. of Aerospace and Mechanical Engineering University of Notre Dame Notre Dame, IN 46556; tel: (574) 631-9489.	
18 – 19 June	Solid Particle & Liquid Droplet Erosion: Testing, Modeling, and Applications - Milano, ITALY	Sponsored by EPRI at the Centro Congressi Fast, p.le R. Morandi 2, Milano 20121 Italy (02 77790304/305)	davgandy@epri.com
20 -22 June	26th International Conference on Surface Modification Technologies – Lyon, France	Vincent FRIDRICI,Maître de Conférences, École Centrale de Lyon, Laboratoire LTDS- Département STMS, Bâtiment H10, 36 avenue Guy de Collongue, 69134 Ecully cedex; Tél.: 04 72 18 62 90 - Fax: 04 78 43 33 83	http://smt26.ec-lyon.fr/
25 – 29 June	Short Course: "Tribology: Friction, Wear, and Lubrication" – Cambridge, MA	MIT Professional Education, Attn: Short Programs; 77 Massachusetts Ave, Building 35-433,Cambridge, MA 02139 USA Telephone: 617-253-210;Fax: 617-258-8831	E-mail: shortprograms@mit.edu
8 – 13 July	Gordon Research Conference on Tribology – Waterville, ME	Chair – Alfons Fischer; University of Duisberg-Essen Germany Theme: "Paths of Dissipation"	E-mail: ALFONS.FISCHER@UNI-DUE.DE http://www.grc.org/chairs.aspx?id=12204
3 – 5 Sep	Tribology and Design 2012 – Kos, Greece	Conference Secretariat: **Irene Moreno Millan,**Wessex Institute of Technology, Ashurst Lodge, Ashurst Southampton, SO40 7AA UK; Tel: 44 (0) 238 0293223	E-mail: imoreno@wessex.ac.uk http://www.wessex.ac.uk/tribology2012rem3.html

Tribology events calendar – Courtesy of ASTM Committee G-2 on Wear and Erosion

4 – 7 Sep	39th Leeds-Lyon Symposium on Tribology – Leeds UK	Topic: Great Challenges in Tribology, Contact: Prof. M. Priest, School of Mechanical Eng'g, The University of Leeds, Leeds, LS2 9JT, UK; Tel: +44 (0)113 3432178;Fax: +44 (0)113 2424611	http://www2.mech-eng.leeds.ac.uk/leeds-lyon/
19 – 21 Sep	ASTM G2 Meeting – Needham, MA	CSM Instruments to host. Contact Dr. N. Randall CSM, or ASTM G2 staff manager Alyson Fick.	E-mail: afick@astm.org http://www.astm.org
7 – 10 Oct	International Joint Tribology Conf. – Denver, CO	Annual ASME/STLE joint tribology conference	www.stle.org
7 – 11 Oct	Mat'ls Sci and Tech Conf. (MS&T) – Pittsburgh, PA	ASM International, Materials Park, OH	www.asminternational.org
18 – 19 Oct	BALTMATRIB (21st Intl Conf. on Engineering Matls and Tribology – Tallinn ESTONIA	Contact: DSc. Irina HUSSAINOVA, Department of Materials Engrg, Tallinn University of Technology, Ehitajate tee, 5 Estonia Office: V - 313A; Tel.: 372 620 3371	E-mail: Irina.Hussainova@ttu.ee
28 Oct – 2 Nov	AVS 59th Internal Symp and Expo. – Tampa, FL	Series of 5 focus sessions in tribology. Prof. Susan B. Sinnott, Dept Matls Sci and Engrg, U. of Florida, PO Box 116400, Gainesville, Florida 32611-6400; Tel. 352-846-3778	Email: ssinn@mse.ufl.edu http://www2.avs.org/symposium/AVS59/pages/call_abstract.html
9 – 15 Nov	ASME Congress: Design, Matls, & Manufacturing (Friction, Lubr.,Wear) – Houston, TX	Contact: Prof. Jeffrey L. Streator, Georgia Institute of Tech., Atlanta, GA 30332-0405; tel: 404-894-2742	jeffrey.streator@me.gatech.edu
		Calendar year 2013	
14 – 18 April	Int'l Conf. on Wear of Materials – Portland, OR	(See the conference website for details). Abstracts due 1 June 2012.	http://www.wearofmaterials.org/
5 – 9 May	STLE Annual Meeting & Exhibition – Detroit, MI	Society of Tribologists and Lubrication Engineers, 840 Busse Highway,Park Ridge, IL 60068-2376; Tel (847) 825-5536	www.stle.org
May (tbd)	ASTM G2 Meeting – West Conschocken, PA (Headquarters) *	Contact: Alyson Fick, ASTM Intl, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959; tel. 610-832-9710	E-mail: afick@astm.org http://www.astm.org
8 – 13 Sep	5th World Tribology Congress – Torino ITALY	BEST CONGRESS COMPANY s.r.l. , Torino – Corso Re Umberto 98; Tel. (mobile) + 39 3920735502	E-mail: info@wtc2013.it E-mail: segreteria@bccgroup.it http://www.wtc2013.it/
		Calendar year 2014	
18 – 22 May	STLE Annual Meeting & Exhibition – Lake Buena Vista, FL	Society of Tribologists and Lubrication Engineers, 840 Busse Highway,Park Ridge, IL 60068-2376; Tel (847) 825-5536	www.stle.org

* ***Tentative meeting date***: Please check within 2 months of this date to confirm. Details may change based on ASTM G2 committee discussions.

Please note: The information in this listing was compiled from a variety of sources and is subject to change. Please contact the organizer to verify dates, times, and details.