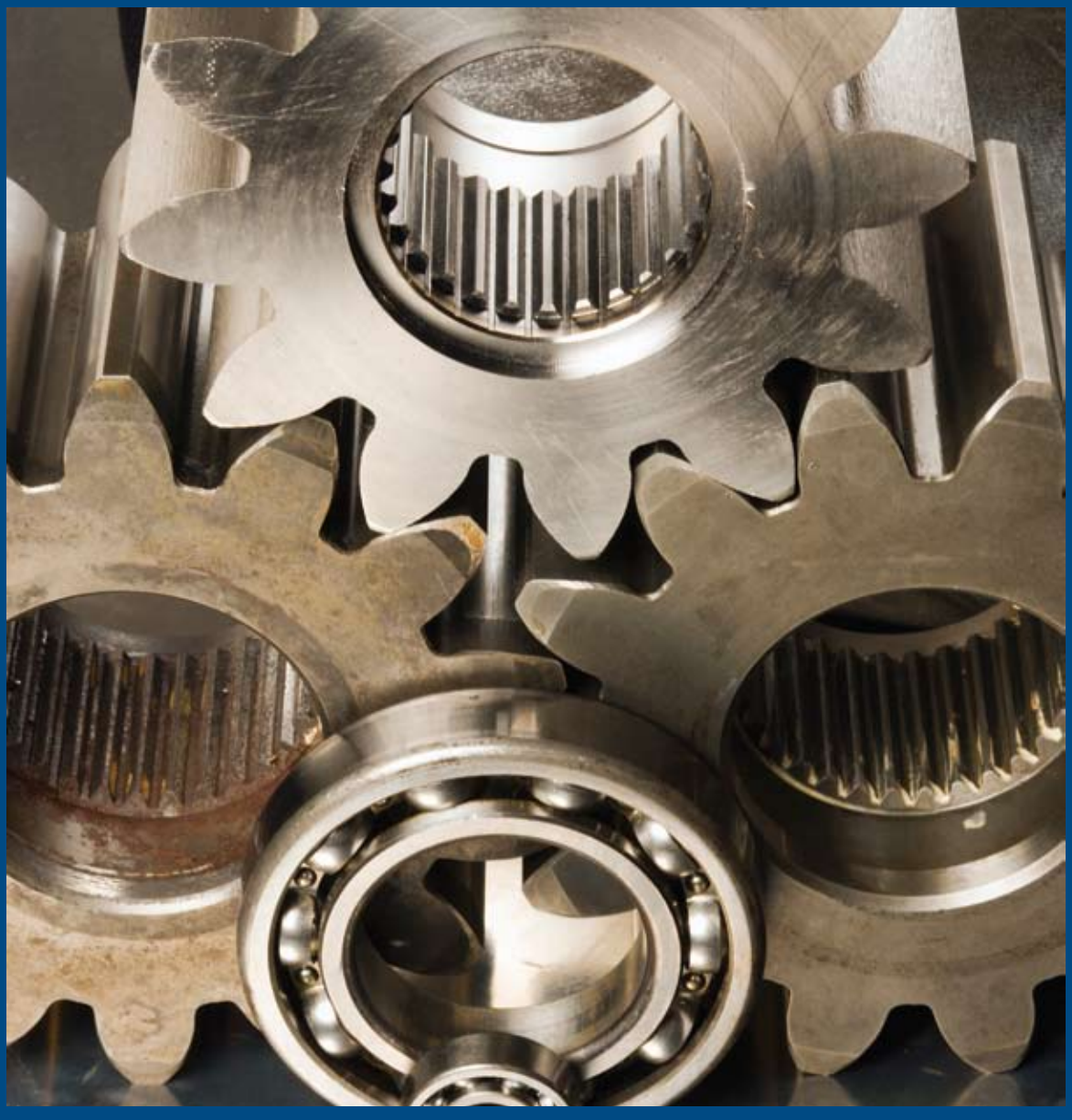
American
Gear Manufacturers
Association

2009 Fall Technical Meeting

Learn from the Best

Gear Experts in the Industry

September 13-15, 2009 • Indianapolis, Indiana



2009 Fall Technical Meeting
Schedule of Events

Sunday, September 13

9:00 a.m. – 5:00 p.m.
Registration

1:00 p.m. – 5:00 p.m.
Session I – Manufacturing & Inspection

6:30 p.m. – 8:00 p.m.
Welcoming Reception

Monday, September 14

7:00 a.m. – 5:30 p.m.
Registration

7:00 a.m. – 8:00 a.m.
Continental Breakfast

8:00 a.m. – 12:00 p.m.
Session II – Design Issues

12:00 p.m. – 1:30 p.m.
Annual Awards Luncheon

1:30 p.m. – 5:30 p.m.
Session III – Materials & Heat Treament

Tuesday, September 15

7:00 a.m. – 12:00 p.m.
Registration

7:00 a.m. – 8:00 a.m.
Continental Breakfast

8:00 a.m. – 12:00 p.m.
Session IV – Application Considerations

Tuesday afternoon open time to visit Gear Expo 2009. Admission is free to those attending the FTM.

The FTM is the best educational opportunity available to you today!

- Hear presentations and interact with speakers on such topics as micropitting, gearbox design, materials, and manufacturing;
- Network with your peers to exchange ideas and learn from each other;
- Find out more about the critical technical issues that you encounter everyday; and
- Learn more about methods and cutting edge technology that will help you operate better tomorrow.

Session I - Manufacturing & Inspection

Influence of the Residual Stresses Induced by Hard Finishing Processes on the Load Carrying Capacity of Gears

Fritz Klocke, Christof Gorgels, Vasilios Vasiliou, RWTH Aachen University

Low noise and high load carrying capacity are two important characteristics of competitive power transmissions. The challenge in the development, design and manufacturing of these power transmissions is to meet these requirements economically. One of the ways to meet both of these requirements is through a process known as hard finishing. There are various types of hard finishing and it is important to know which process produces which requirement.

The aim of this research project was to induce residual stresses in the edge of the work pieces by different hard finishing processes and analyze their influence on the durability of the gears. The tested gears were manufactured by profile grinding, gear honing and generating grinding. The presentation will show the results of the load carrying capacity tests depending on the values of the residual stresses.

Implementing ISO 18653, Evaluation of Instruments for the Measurement of Gears

Rob Frazer & Steve Wilson, UK National Gear Metrology Lab

A trial test of the calibration procedures outlined in ISO 18653, Gears- Evaluation of instruments for the measurement of individual gears, showed that the results are reasonable, but a minor change to the uncertainty formula is recommended.

Gear measuring machine calibration methods are reviewed. The benefits from using work-piece like artifacts are discussed and a procedure for implementing the standard in the work place is presented.

Problems with applying the standard to large gear measuring machines are considered and some recommendations are offered.

Producing Profile and Lead Modifications in Threaded Wheel and Profile Grinding

Antoine Türich, Gleason Corporation

Modern gear boxes are characterized by high torque load demands, low running noise, and compact design. In order to fulfill these demands, profile and lead modifications are being applied more and more. The main reason for the application of profile and/or lead modification is to compensate for the deformation of the teeth due to load, thus ensuring proper meshing of the teeth which will result in optimized tooth contact pattern.

This paper will focus on how to produce profile and lead modifications by using the two most common grinding processes, threaded wheel and profile grinding. In addition, more difficult modifications, such as defined flank twist or topological flank corrections, will also be described in this paper.

New Developments in Gear Hobbing

Oliver Winkel, Liebherr Verzahntechnik GmbH

Several innovations have been introduced to the gear manufacturing industry in the past few years. In the case of gear hobbing, dry cutting technology and the ability to do it with powder-metallurgical HSS-materials might be two of the most impressive ones. But the technology is still moving forward. The aim of this paper is to present recent developments in the field of gear hobbing, focusing on innovations regarding tool materials, process technology and process integration.

HYPOLOID™ Gears with Small Shaft Angles and Zero to Large Offsets

Hermann Stadtfeld, Gleason Corporation

Beveloid gears are used to accommodate a small shaft angle. The manufacturing technology used for beveloid gearing is a special set up of cylindrical gear cutting and grinding machines.

A new development, called Hypoloid gearing, addresses the desire of gear manufacturers for more freedom in shaft angles. Hypoloid gear sets can realize shaft angles between zero and 20° and at the same time allow a second shaft angle (or an offset) in space which provides the freedom to connect two points in space.

In all wheel driven vehicles that traditionally use a transfer case with a pinion/idler/gear arrangement or a chain, the exit of the transfer case needs to be connected with the front axle. This connection necessitates the use of two CV joints. Compared to a single CV joint, the two CV connections are more costly and less efficient.

The newly developed Hypoloid gearings can remedy the situation by offering more freedom in shaft angle and additional offset which eliminates the need for an additional CV joint. In addition to the automotive drive trains, Hypoloid technology can be applied to aircraft as well as general gearbox manufacturing.

Session II - Design Issues

Dependency of the Peak-to-Peak Transmission Error on the Type of Profile Correction and Transverse Contact Ratio of the Gear Pair

Ulrich Kissling, KISSsoft AG

Profile corrections on gears are a commonly used method to reduce transmission error, contact shock, and scoring risk. There are different types of profile corrections. It is a known fact, that the type of profile correction used will have a strong influence on the resulting transmission error. The degree of this influence may be determined by calculating tooth loading during mesh. The current method for this calculation is very complicated and time consuming; however, a new approach has been developed which could reduce the calculation time.

This approach uses an algorithm which includes the conventional method for calculating tooth stiffness in regards to bending and shearing deformation, flattening due to Hertzian pressure, and tilting of the tooth in the gear body. The new method was tested by comparing its results with FEM and LVR. This paper illustrates and discusses the results of this study.

Optimizing Gear Geometry for Minimum Transmission Error, Mesh Friction Losses and Scuffing Risk

Rob Frazer, UK National Gear Metrology Lab, Mike Fish and Dave Palmer, Dontyne Systems, Ltd

Minimizing gear mesh friction losses is important if plant operating costs and environmental impact are to be minimized. This paper describes how a validated 3D FEA and TCA can be used to optimize cylindrical gears for low friction losses without compromising noise and power density. Some case studies are presented and generic procedures for minimizing losses are proposed. Future development and further validation work is discussed.

Load Sharing Analysis of High Contact Ratio Spur Gears in Military Tracked Vehicle Application

M. Rameshkumar, P. Sivakumar, S. Sundareshm, Combat Vehicles Research and Development Establishment, and K. Gopinath, IIT

Military tracked vehicles demand a very compact transmission to meet mobility requirements. Some of the desirable characteristics of these transmissions include: increased rating, improved power to weight ratio, low operating noise and vibration, and reduced weight. To achieve all or some of these characteristics, it is has been decided to apply a High Contact Ratio (HCR) spur gearing concept which will improve load carrying capacity, lower vibration, and reduce noise. Similar to helical gears, the load in HCR gearing is shared by minimum two pair of teeth. Therefore, load sharing analysis was conducted on Normal Contact Ratio (NCR) gearing used in sun - planet gears of an existing drive.

This paper deals with analysis of load sharing of individual teeth in mesh for different load conditions throughout the profile for both sun and planet gears of NCR/HCR gearing using Finite Element Analysis. Also, the paper reveals the variation of bending stress and deflection along the profile of both gearing designs.

Designing for Static and Dynamic Loading of a Gear Reducer Housing with FEA

M. Davis, Y.S. Mohammed, A.A. Elmustafa, Old Dominion University and C. Ritinski, Sumitomo Machinery Corporation America

A recent trend has been toward more user friendly products in the mechanical power transmission industry. One of these products is a high horsepower, right angle, shaft mounted drive designed to minimize installation efforts. Commonly referred to as "alignment free" type, this drive assembly offers quick installation with minimum level of expertise required. It is also more cost effective. These characteristics make this type of drive ideal for use in applications such as underground mining where there is little room to maneuver parts.

An alignment free drive is direct coupled to the driven shaft only; it is not firmly attached to a foundation or rigid structure. A connecting link or torque arm connects the drive to a fixed structure, which limits the drive's rotational movement about the driven shaft. The electric motor is supported by the reducer housing through a fabricated steel motor adapter; the coupling connecting the motor shaft and reducer shaft is enclosed by this motor adapter.

FEA was used to identify potential problem areas of the cast iron housing before production began. The results were compared to field data and the findings were used to redesign the motor adaptor to lower stresses.

The Effect of Flexible Components on the Durability, Whine, Rattle and Efficiency of a Transmission Geartrain System

Brian Wilson, Romax Technology, Inc.

Quality requirements and expectations in terms of durability, lower operating noise and vibration, and efficiency have increased. With increased complexity and quality requirements, a gear engineer must use advanced system design tools to ensure a robust gear train is delivered on time, meeting all quality, cost, and weight requirements.

As a standard practice, finite element models have traditionally been used for analyzing transmission system deflections. But this modeling environment does not always include provisions for analysis of vibration, efficiency, or any considerations for attribute variation. And that often requires many runs of the test to ensure all variations have been included and tested.

An advanced software tool is available for the analysis of transmission system durability, noise, vibration, and efficiency, all within a single programming environment, including the effects of flexible components such as housings, gear blanks, and shafting, while also allowing manufacturing variation studies to be performed. This paper includes the results of a case study of this program.

Session III - Materials & Heat Treatment

Unique Design Constraints for Molded Plastic Transmissions

Rod Kleiss, Eric Wiita, Kleiss Gears, Inc.

Molded plastic gears and transmissions must work effectively in extremely variable conditions just as their counterparts in steel. Plastics have the added variables of large thermal expansion and contraction, moisture absorption, greater tolerance variation, lower strength, and form deviations due to the molding process. The design of a molded transmission must consider these effects and characteristics. This paper will offer an example of the development of a molded plastic gear pump intended for the very steady delivery of 50 psi water pressure for a medical application. It will present an approach in design, tolerancing, material selection, molding procedure, and testing to achieve and verify an effective as-molded transmission.

The Anatomy of a Micropitting Induced Tooth Fracture Failure - Causation, Initiation, Progression and Prevention

Raymond J. Drago, Roy J. Cunningham, and Steve Cymbala, Drive Systems Technology, Inc.

Micropitting has become a major concern in certain classes of industrial gear applications, especially wind power and other relatively highly loaded somewhat slow speed applications, where carburized gears are used to facilitate maximum load capacity in a compact package. While by itself the appearance of micropitting does not generally cause much perturbation in the overall operation of a gear system, the ultimate consequences of a micropitting failure can, and frequently are, much more catastrophic.

This paper presents a discussion of the initiation, propagation and ultimate tooth fracture failure mechanism associated with a micropitting failure. The subject is presented by way of the discussion of detailed destructive metallurgical evaluations of several example micropitting failures that the authors have analyzed on both parallel axis and bevel gears.

Bending Fatigue, Impact Strength and Pitting Resistance of Ausformed Powder Metal Gears

Nagesh Sonti, Suren Rao, Pennsylvania State University, and Gary Anderson, Keystone Powdered Metal Company

The powder metal (P/M) process is making inroads in automotive transmission applications because of substantially lower cost of P/M steel components for high volume production as compared to wrought or forged steel parts. Although P/M gears are increasingly used in powered hand tools, gear pumps, and as accessory components in automotive transmissions, P/M steel gears are currently in limited use in vehicle transmission applications.

The primary objective of this project was to develop high strength P/M steel gears with bending fatigue, impact, and pitting fatigue performance equivalent to current wrought steel gears. Ausform finishing tools and process were developed and applied to powder forged (P/F) steel gears in order to enhance the strength and durability characteristics of P/M gears, while maintaining the substantive cost advantage for vehicle transmission applications.

This paper presents the processing techniques used to produce Ausform finished P/F steel gears, and comparative bending fatigue, impact and surface durability performance characteristics of Ausform finished P/F steel gears, as well as conventional wrought steel gears.

Design Development and Application of New High-Performance Gear Steels

Jason Sebastian, Chris Kern, James Wright and Rich Kooy, QuesTek Innovations LLC

A new class of high strength, secondary hardening gear steels that are optimized for high-temperature, low-pressure (i.e., vacuum) carburization is being developed. These alloys were computationally designed as secondary-hardening steels at three different levels of case hardness. The exceptional case hardness, in combination with high core-strength and toughness properties, offer the potential to reduce drive train weight or increase power density relative to incumbent alloys such as AISI 9310 or Pyrowear® X53.

This new class of alloys utilizes an efficient nano-scale M2C carbide strengthening dispersion, and their key benefits include: high fatigue resistance (contact, bending, scoring); high hardenability achieved via low-pressure carburization (thus reducing quench distortion and associated manufacturing steps); a tempering temperature of >900°F to provide up to a 500°F increase in thermal stability relative to incumbent alloys; and core tensile strengths in excess of 200 ksi. Ferrium C69™, is one alloy in this family that can achieve a carburized surface hardness of HRC 67 (with a microstructure substantially free of primary carbides), has exceptionally high contact fatigue resistance which make it an excellent candidate for applications such as camshafts and bearings as well as gear sets.

Session IV - Application Considerations

High Performance Industrial Gear Lubricants for Optimal Reliability

K.G. McKenna, J. Carey, N.Y. Leon and A.S. Galiano-Roth, ExxonMobil Research and Engineering

In recent years gearbox technology has advanced and Original Equipment Manufacturers have required gear oils to meet the lubrication requirements of these new designs. Modern gearboxes operate under severe conditions and maintain their reliability to ensure end-user productivity. The latest generation of industrial gear lubricants can provide enhanced performance even under extreme operating conditions for optimal reliability and reduced cost of operation.

This paper describes how gear lubricants function in gearboxes and discusses the facts vs. myths of industrial gear lubricants. The paper will show how advanced gear lubricant technology can optimize the life of the gears, bearings and seals, resulting in reduced cost of operation. Opportunities to use advanced synthetic gear lubricants to achieve operational benefits in the areas of improved energy efficiency, wider operating temperature ranges, extended oil drain intervals and equipment life will be discussed.

Allowable Contact Stresses of Jacking Gear Units Used in the Offshore Industry

Alfred Montestruc, Friede & Goldman, Ltd.

An offshore jack-up drilling rig is a barge upon which a drilling platform is placed. The barge has legs which can be lowered to the sea floor to support the rig. Then the barge can be "jacked-up" out of the water providing a stable work platform from which to drill for oil and gas. The rack and pinion systems used to raise and lower the rig are enormous in terms of gear pitch or module by gear industry standards. Quarter pitch (101.6 module) pinions are common. Lifetime number of cycles for these units are -- again, by gear industry standards – small, as rack teeth typically have 25 year lifetime cycles measured in the low hundreds. That is off the charts for AGMA (and ISO or DIN) design rules which draw a straight line to zero cycles for contact stress cycles less than 10,000. Use of any standards was abandoned from the start in the offshore industry for jacking applications. The author presents methods, and experience of that industry and suggested allowable contact stresses in such applications.

Variation Analysis of Tooth Engagement and Load-Sharing in Involute Splines

Kenneth Chase, Carl Sorenson and Brian DeCaires, Brigham Young University

Involute spline couplings are used to transmit torque from a shaft to a gear hub or other rotating component. External gear teeth on the shaft engage an equal number of internal teeth in the hub. Because multiple teeth engage simultaneously, they can transmit much larger torques than a simple key and keyway assembly. However, due to manufacturing variations, the clearance between each pair of mating teeth varies, resulting in only partial engagement.

A new model for tooth engagement, based on statistics, predicts that the teeth engage in a sequence, determined by the individual clearances. As the shaft load is applied, the tooth pair with the smallest clearance engages first, then deflects as the load increases, until the second pair engage. Thus, only a subset of teeth carry the load. In addition, the load is non-uniformly distributed, with the first tooth carrying the biggest share. As a consequence, the load capacity of spline couplings is greatly reduced, though still greater than a single keyway.

This paper discusses the results of a statistical model which predicts the average number of teeth which will engage for a specified load, plus or minus the expected variation. The model quantitatively predicts the load and stress in each engaged pair.

Does the Type of Gear Action Affect the Appearance of Micro-Pitting and Gear Life?

Allen Williston, A&J Engineering

Early results from testing conducted have raised questions concerning the role of gear action with the appearance of micropitting as well as surface fatigue (macropitting). Comparisons between similar gear sets with the same loads, speeds, and lubrication but operated either as speed increasers or as speed reducers have yielded strikingly different propensities for wear. Further, these observations are not limited to lubrication based failures such as micropitting, but, so far, have applied to traditional surface fatigue failures (macropitting) as well.

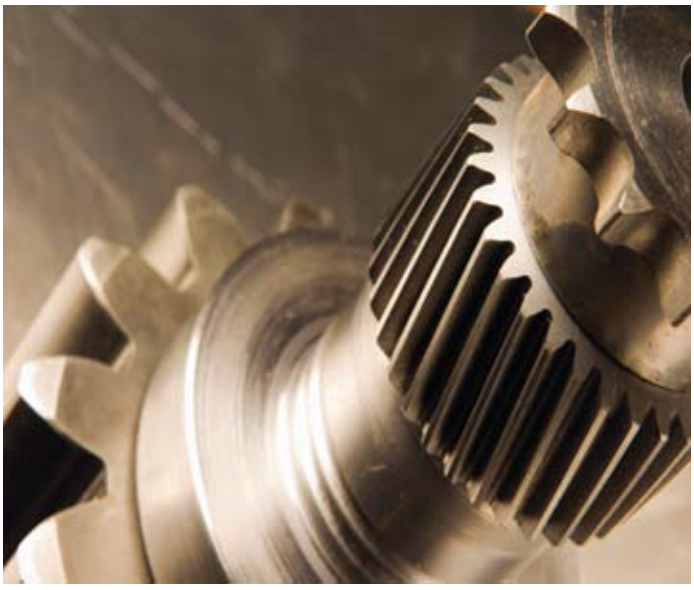
Findings point to an increase in the presence of micropitting on gearing operated as speed reducers. All components are operating at the same speed and load, yet wear is greatly reduced for the driven components.

In addition to how gear action affects micropitting in gearing is the question of how the gear action affects fatigue life. Current gear rating standards are based upon statistical analysis of real-world experience and mathematical stress-versus-cycle calculations. If gear action affects how gearing fails in fatigue, there may be significant ramifications in the industry. However, before any such conclusion may be made, additional testing is necessary.

The Effect of Gearbox Architecture on Wind Turbine Enclosure Size

Charles D. Schultz, Beyta Gear Service

Gearbox architecture - the type of gearing used, the overall gear ratio, the number of increaser stages, the number of meshes, the ratio combinations, and the gear proportions- can have a profound effect on the "package" size of a wind turbine. In this paper the author applies a common set of requirements to a variety of potential gearbox designs for a 2.0 MW wind turbine and compares the resulting "geared component" weights, gearbox envelope sizes, generator sizes, and generator weights. Each design option is also evaluated for manufacturing difficulty via a relative cost estimate.



American Gear Manufacturers Association

Fall Technical Meeting Registration Form

Program Details

Dates & Times:

Sunday, September 13

Session I – Manufacturing & Inspection
1:00 pm —5:00 pm

Welcoming Reception
6:30 pm – 8:00 pm

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Annual Awards Luncheon
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Tuesday, September 15

Continental Breakfast
7:00 am – 8:00 am

Session IV – Application Considerations
8:00 am – 12:00 pm

Hotel Information:
Marriott Indianapolis Downtown
350 Maryland Street
Indianapolis, Indiana 46225

Reservations:
317.822.3500
(Mention AGMA or Gear Expo)
F: 317.822.1002

Room Rate:
$185 single/double

Cut-off date:
August 21, 2009

To Register

Online: www.agma.org

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Registration Fees

☐ Member Registrant	$625.00	_____
☐ Nonmember Registrant	$915.00	_____
	Total:	_____

Payment Method

Fees include a full set of the technical papers to be presented and the Annual Awards Luncheon. Student registrations do not include the Awards Luncheon.

☐ Check Enclosed ☐ Credit Card (AMEX, Discover, Master Card or Visa)

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Cancellation Policy: All cancellations must be in writing and received by AGMA prior to August 15, 2009. A $50 U.S. processing fee will be assessed for each cancelled registration that results in a refund. Refunds will not be issued if cancellation occurs on or after August 15, 2009.

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