Keith G. Cline

P.E.

ROM, Senior Managing Consultant

Mr. Cline is a Senior Managing Consultant and metallurgical engineer with experience in failure analysis, laboratory testing, consulting, and manufacturing. His failure analysis experience includes metallic, plastic, and composite materials from various applications including structural, transportation, aerospace, industrial, industrial piping, and residential plumbing. He is also experienced in heat-treating of numerous metal alloy systems, corrosion failure mechanisms, welded and mechanically fastened joining, and performance testing of materials and products. Additionally, he has experience with analytical equipment including optical and scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC).

Mr. Cline's prior experience includes being responsible for the development of fasteners and fastening systems, as well as the maintenance of process and part specifications for The Boeing Company. Projects included development and qualification of a wing fastening system, design, and implementation of repair rivets for fuselage and wing structures, and laboratory fatigue testing of fuselage and wing joint coupons.

Education

Bachelor of Materials Engineering, Auburn University, 1991

Licenses & Certifications

- State of Washington P.E. License No. 39067
- State of Oregon P.E. License No. 103960PE
- State of Alabama P.E. License No. 24046

Positions Held

Engineering Systems Inc., Seattle, Washington

- Regional Operations Manager & Senior Managing Consultant, 2016 – Present

MDE Inc., Seattle, Washington

- President & Principal, 2002– 2016

Contact Information

kgcline@engsys.com

(206) 622-2007

ESi Seattle

700 South Industrial Way
Seattle, WA 98108

Areas of Specialization

- Failure analysis of materials and components
- Fasteners and welded joints
- Heat-treatment consultation
- Industrial equipment
- Material selection
- Plumbing pipe and fixtures
- Sprinkler pipe and fittings
- Transportation components
- Microbiologically Influenced Corrosion (MIC)

The Boeing Company, Seattle, Washington

- Fastening Technology Engineer, 2001– 2002

Applied Technical Services, Marietta, Georgia

- Materials Engineer, 1997– 2001

Consulting Metallurgical Services, Marietta, Georgia

- Materials Engineer, 1994– 1997

Training

- **Fracture Analysis of Glass and Ceramic**s, Alfred University, 2006
- **Aerial High Lift Safety and Hazards** Confined Space Hazards, 2004
- **Fire Arson and Explosion Investigation** (NAFI), 2002
- **Aircraft Structures Engineering**, The Boeing Company, 2001
- **Plastics Failure Analysis** (ASM), 2000
- **Regional Color Seminar**, Hunter Color Institute, 1998
- **Major Testing Methods for Plastics** (ASTM), 1997

Professional Affiliations/Honors

American Society for Materials (ASM International)

- Member

American Society for Testing and Materials (ASTM International)

- Member

National Association of Corrosion Engineers (NACE)

- Member

Society of Plastics Engineers (SPE)

- Member

The Materials Society(TMS)

- Member

Project Experience

Product and Equipment Experience

- **An extendable ladder failed**, leading to the user falling and being injured. The investigation included several laboratory inspections where one of the locking pins was determined to intermittently fail to engage and create an unstable joint at one of the rungs. Corrosion of a spring within the locking mechanism was discovered, which caused excessive resistance and impeded normal operation. Testing of the subject and exemplar ladders found that the ladder became unstable when loaded on the corrosion-damaged locking pin side.
- **Manufacturing damage to commercial mirrors** used in a hotel led to their being removed from service and returned. The mirrors were highly reflective and readily showed any scratches or surface variation. The investigation included testing of the raw mirror product at the material supplier's location and also of hundreds of the returned, finished products at the facility where the raw material was assembled into the final product. The investigation included comparing purposely induced damage during site testing to that found on the finished product. Interpretations of industry standards for manufacturing and inspection were central to determining most of the damage occurred during final product assembly and not during initial processing.
- **A rider fell off a horse** during a barrel racing competition when a saddle strap buckle unexpectedly failed. Evaluation of the buckle determined it had fractured in multiple locations. The buckle, made from cast stainless steel, had fractured in a brittle manner. Several evaluations of the buckle were performed including optical and scanning electron microscopy, compositional analysis, and microstructural analysis. The testing results determined multiple manufacturing defects, including porosity and excessively large grain size, contributed to the failure.

Plumbing, Piping, and Water Losses

- **A stainless-steel reinforced water supply hose failed** in a bathroom causing damage to a home. The cause of the failure was corrosion damage to the stainless-steel reinforcing wires, leading to wire fracture and rupture of the underlying plastic hose. Large concentrations of chlorine were present on the reinforcing wire, leading to the initial conclusion that the wire was not sufficiently resistant to normal and expected household cleaning chemicals. However, an additional site inspection was performed where the replacement hose was found to be similarly damaged and near failure. It was determined that renovation to the bathroom before the leak occurred likely introduced corrosive hydrochloric acid that was not remediated after the remodel was performed.
- **Several condominium developments in the same city experienced leaks** from joints in their water distribution systems. The piping joints were mechanically crimped with EPDM (ethylene propylene diene monomer) O-rings within the joint creating the water-tight seal; some of these Orings were degrading allowing the water to leak. Evaluations included microscopic and analytical testing that determined the EPDM O-rings met prevailing industry standards for composition and performance, but that the system design and installation created conditions that created excessive stresses within the O-rings that accelerated degradation and caused the failures.

Automotive and Transportation Components

- **A two-truck head-on collision** occurred on a rural road after one of the vehicles left and then reentered the roadway. The passenger side steering link tie rods had fractured and the investigation focused on this component, specifically to determine if the fracture occurred before the collision and if this could have led to loss of steering control. Several inspections were performed of all available components to assess where damage was present and determine when it may have occurred, this included reconstruction of the components to ascertain the loading direction(s). The investigation determined the tie rod end fractured during the collision, not before, based upon the fracture analysis.
- **A car was struck on the front bumper** and subsequently repaired. The owner alleged later, after the vehicle had been sold to an out-of-state party, that although the repair was performed properly, the vehicle had incurred intrinsic, undetected damage that negatively affected its safety in a collision and longevity of service. An extensive technical documentation review of industry repair standards and the effects of structural repairs on vehicle performance was performed. Additionally, the vehicle was found and all areas and components where the alleged damage could have manifested were inspected and documented. None of the proposed damage was present on the vehicle, refuting the claim that the vehicle had been permanently altered or degraded away from the original impact location.

Publications/Presentations

"Pitting Corrosion Failure of AISI Type 304 L Stainless Steel Tubing" by **K.G. Cline**, MS&T Conference, 2005

"Failure Analysis of High-Capacity Forklift" by **K.G. Cline,** IMS Conference, 2004

"Metallurgical Failure of Titanium Wing Attachment Bolts" by **K.G. Cline**, M.E. Stevenson, J.L. McDougall, Practical Failure Analysis, ASM International, August 2003

"Sprinkler Piping Corrosion and Degradations" by **K.G. Cline**, Seattle SFPE, February 2003

“Confirmation of the Presence of Styrene Butadiene Resin (SBR) Polymer in Drywall Primer Applications” by D.C. Mann, **K.G. Cline**, Perkin Elmer Application Note

“Illumination Caused Permanent Bodily Injury, Photons Not Taken Lightly” by L.F. Bilancia, A.M. Giesa, **K.G. Cline**, IEEE, 2019

“Failure of Beet Planter Support Wheel Kingpins” by **K. G. Cline**, MS&T Conference, 2019

“When Cleaning Makes a Mess: Case Studies Involving Cleaning Agents” by E.E. Wright, M.A. Hineman, **K.G. Cline**, D.E. Alexander, B.M. May, MS&T Conference, 2019

“Metal Oxide Varistors in Fires – Cause v. Fire Victim” L.F. Bilancia, P.R. Ritchie, E.M Schultz, **K. G. Cline**. 2025 IEEE Internationals Symposium on Product Compliance Engineering (ISPCE), 2025

“Metallurgical Evaluation of Lightning-Related Damage to a Copper Water Pipe” McDougall, Jeffrey & **Cline**, **Keith** & Hopkins, Perry & Counts, Steven. (2025 Journal of Failure Analysis and Prevention) 2025