

Dr. Christopher DellaCorte
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Biographical Statement

Dr. Christopher DellaCorte is NASA's Senior Technologist for Tribology and Rotating Machinery. He is a highly visible and widely recognized leader in the field of tribology, mechanical components and aerospace technology. His academic background includes degrees in Fluid and Thermal Sciences, Mechanical and Aerospace Engineering with a deep emphasis in Materials Engineering. His career experience includes research on longstanding extreme tribology challenge areas such as the high temperatures, high speeds and high loads often encountered in spacecraft and aircraft. He has worked at the NASA Glenn Research Center since 1985.

He has published over 140 journal articles, government technical reports, book chapters and conference papers. His innovative research has resulted in eleven patents related to tribological coatings, high performance bearing alloys, materials processing, and mechanical components. He has a strong track record in forensic failure analysis of mechanical systems and has been frequently called upon to solve important and vexing NASA and industrial problems.

Dr. DellaCorte's research has been awarded major recognition by industry (R&D 100 awards), government and prominent professional societies. His work on coatings technology was recognized as NASA's Government and Commercial Invention of the Year for 2018 and his pioneering work on NiTi alloys received the 2019 ASM Engineering Materials Achievement Award. He has helped solve major bearing and other mechanical system problems on the International Space Station (ISS) and for NASA's new Space Launch System (SLS). His forensic work has been recognized by NASA with many awards including the prestigious Silver Snoopy bestowed by the astronaut corps.

Dr. DellaCorte is deeply engaged with professional technical societies. He is a fellow of both the American Society of Mechanical Engineers (ASME) and the Society of Tribologists and Lubrication Engineers (STLE). He was the founding Editor of STLE's highly regarded Tribology & Lubrication Technology (TLT) magazine and has served as the Editor-In-Chief of STLE's peer reviewed journal Tribology Transactions since 2016.

Education:

Ph.D. Mechanical & Aerospace Engineering, Case Western Reserve University (1989)
M.S. Mechanical Engineering, Case Western Reserve University (1987)
B.S. Fluid and Thermal Sciences, Case Western Reserve University (1986)

Post Graduate Training:

Cryogenics Engineering, Statistical Experimental Design, Auger Electron Spectroscopy, Project Management, Government Contracting, Engineering Management and leadership.

Current Research & Engineering Focus:

- Develops NiTi alloys for advanced mechanical component applications.
- Performs enabling high temperature tribomaterials research for NASA's space and aeronautics missions.
- Provides subject matter expertise reviews and engineering oversight to major NASA missions in space power, satellite sensing and in-space propulsion systems.
- Provides forensic engineering analyses of aerospace system failures and consultancy for future projects involving mechanical and tribological challenges.
- Leads the transition of NASA tribology technology into industrial applications.

Major Technical Highlights:

- Developed next generation high temperature solid lubricant tribomaterials (PS/PM300 series and later PS/PM400) that have enabled new applications for foil gas bearings, and new industrial solutions to high temperature wear problems. This technology resulted in three patents, an R&D100 award and was selected as the 2018 NASA Invention of the Year.
- Led government-industry effort that demonstrated the world's first foil bearing supported Oil-Free turbocharger (1999) now entering commercialization and resulted in the spin-off many new oil-free industrial products.
- Established the first-ever load capacity, stiffness Rule of Thumb (ROT) models for foil gas. Based upon first principles and experimental data, these models are in widespread use and have accelerated commercialization of Oil-Free technology.
- Played leading role in identifying root cause failure of critical tribological component (Solar Alpha Rotary Joint, SARJ) on International Space Station (ISS) and in understanding fastening loosening phenomena encountered by the NASA Orion crew capsule.
- Pioneered the development and use of low modulus, superelastic, hard NiTi intermetallics for rolling element bearings. This work led to the development of a new class of bearing and mechanical component materials that address unmet challenges with respect to corrosion resistance and extreme load capacity. Applications include spacecraft, underwater operation, wind turbines and electric vehicles.

Academic Mentorship and Engagement:

- Serve on the External Advisory Board for Case Western Reserve University (CWRU) Department of Mechanical & Aerospace Engineering. Review curriculum, assist in strategic planning and provide feedback on program direction. (2009-present)
- Directly supervised and co-advised 13 Masters and 10 Ph.D. students at six different universities in the US and abroad (France and New Zealand). All are now actively contributing to industry, academia, and government. Many continue to work in tribology.
- Regularly hosted and mentored undergraduates and visiting faculty fellows each summer to conduct advanced R&D.

Professional Society Activities and Major Recognition (current and former):

- Editor-In-Chief, STLE **Tribology Transactions** journal (2016-present)
- Fellow (2005) and Life Member STLE (2017)
- Member STLE Board of Directors, (2008-2014)
- Chair ASME/STLE Joint Tribology Conference (2001)
- Fellow ASME (2006)
- ASME Research Committee on Tribology
- ASME Tribology Division Honors and Awards Committee
- Founding Editor STLE **Tribology and Lubrication Technology** publication (2003-2006)
- Associate Editor then Editor-In-Chief of STLE journal **Lubrication Engineering** (1995-2003)

Major Awards/Recognition:

- 1986 ASME Old Guard National Paper Presentation Award
- 1994 STLE Hunt Award for Best Paper
- 1996 ASME Newkirk Award for Tribology
- 1998 George Washington University: Flemming Award for Scientific Excellence and Achievement by Federal Employee
- 1999 STLE Sonntag Award for best paper on solid lubrication
- 2001 STLE Sonntag Award for best paper on solid lubrication
- 2002 STLE Hunt Award for Best Paper
- 2002 NASA TGIR Award for Oil-Free Turbomachinery Achievements
- 2003 R&D 100 Innovation Award for PS/PM300 tribomaterials technology
- 2003 STLE Sonntag Award for best paper on solid lubrication
- 2004 Recipient of Federal Laboratory technology transfer award
- 2005 STLE Sonntag Award for best paper on solid lubrication
- 2005 STLE elevation to Fellow
- 2007 STLE P.M. Ku Award for volunteerism
- 2009 ASME elevation to Fellow
- 2009 NASA Silver Snoopy Award
- 2010 NASA Space Flight Awareness Award
- 2010 NASA Qasar Award for Safety and Quality Assurance
- 2011 NASA NESC Engineering Excellence Award for NiTi bearing development
- 2011 NASA GSFC Award-Mars Rover Sample Analysis at Mars (SAM) Team
- 2014 R&D 100 Innovation Award for NiTi bearings
- 2016 STLE Editor-In-Chief **Tribology Transactions** journal.
- 2017 STLE International Award, elevation to Life Member
- 2018 Aerospace Mechanisms Symposium Best Paper Award
- 2018 NASA Szabo Engineering Excellence Award for Orion Separation Bolt Investigation
- 2018 NASA Inventor of the year for PS/PM400 tribomaterials
- 2019 ASM International-Engineering Materials Achievement Award

Publications and Patents:

- Over 140 refereed archival journal articles (58), NASA/DOD papers (53), conference proceedings (39), and book chapters (3).
- 11 technology patents awarded (more pending)
- Keynote and invited lectures at national and international conferences

Patents:

1. DellaCorte, C., and Sliney, H.E.: "Method of making carbide/fluoride/silver composites," US Patent #5034187, July 23, 1991.
2. DellaCorte, C., and Edmonds, B.J.: "Self-lubricating composite containing chromium oxide," US Patent #5866518, February 2, 1999.
3. DellaCorte, C.: "Dynamic face seal arrangement," US Patent #6007068, December 28, 1999.
4. DellaCorte, C., and Glennon, G.: "Ball bearings comprising nickel-titanium and methods of manufacture thereof," US Patent #8182741, May 22, 2012.
5. DellaCorte, C., and Glennon, G.: "Compositions Comprising Nickel-Titanium and Methods of Manufacture Thereof," US Patent #8377373, February 19, 2013.
6. DellaCorte, C.: "Prestressing Shock Resistant Mechanical Components and Mechanisms Made From Hard, Superelastic Materials," US Patent #8709176, April 29, 2014
7. DellaCorte, C., and Edmonds, B.J.: "High Temperature Solid Lubricant Coating for High Temperature Wear Applications," US Patent #8753417, June 17, 2014.
8. Padula, S.A., Noebe, R.D., Stanford, M.K., and DellaCorte, C.: "Mechanical components from highly recoverable, low apparent modulus materials," US Patent #9169545, October 27, 2015.
9. DellaCorte, C., and Glennon, G.: "Compositions Comprising Nickel-Titanium and Methods of Manufacture Thereof and Articles Comprising the Same," US Patent #9393619, July 19, 2016.
10. Stanford, M.K., Noebe, R.D., DellaCorte, C., Bigelow, G., and Thomas, F.: "High Hardness, High Elasticity Intermetallic Compounds for Mechanical Components," US Patent #10,364,483, July 30, 2019.
11. DellaCorte, C., Stanford, M.K., and Thomas, F.: "Method for making small diameter Nickel-Titanium Metal Alloy Balls," US Patent #11,033,963.
12. DellaCorte, C.: "Method of Making Steel That is Free From Ceramic Particle Contamination," **US Patent Pending**, LEW 19492-1.

Publications:

1. DellaCorte, Christopher and Sliney, H. E.: "Composition Optimization of Self-Lubricating Chromium-Carbide-Based Composite Coatings for Use to 760°C," ASLE Trans., Vol. 30, No. 1, Jan 1987, pp. 77-83.
2. DellaCorte, Christopher and Sliney, H.E.: "Effects of Atmosphere on the Tribological Properties of a Chromium Carbide Based Coating for Use to 760°C," ASLE Preprint 87-AM-8A-1, May 1987. (NASA TM-88894), Lubr. Eng., (44), 4, 338-344, May 1988.
3. DellaCorte, Christopher: "Experimental Evaluation of Chromium Carbide-Based Solid Lubricant Coatings for Use to 760°C," August 1987, NASA CR 180808.
4. DellaCorte, Christopher: "Tribological Composition Optimization of Cr₃C₂ Coatings for Foil Bearings of Use to 650°C," NASA CR 179649, Surface Coatings and Technology, AVS, 36, (1988) 87-97, October 1988.
5. DellaCorte, Christopher, Sliney, H.E.; and, Deadmore, D.L.: "Sputtered Silver Films to Improve Cr₃C₂ Based Solid Lubricant Coatings for Use to 900°C," NASA TM 100783, STLE Preprint 88 AM-7F-2, 1988. STLE Transactions, (31), 3, 329-334.
6. DellaCorte, Christopher: "Tribological Properties of Alumina-Boria-Silicate Fabric from 25 to 850°C," NASA TM 100806, STLE No. 88-TC-3E-1. STLE Transactions, (32), 3, 325-330.
7. Steinetz, B.M., DellaCorte, Christopher, and, Sirocky, P.J.: "On the Development of Hypersonic Engine Seals," NASA TP 2854, 1988.
8. Lhymn, C., Sliney, H., and DellaCorte, C.: "Three-body Abrasion of Fibrous Composites", Advances in Polymer Technology, volume 9, number 2, pp 129-138, 1989.
9. DellaCorte, Christopher, Steinetz, B.M., and, Brindley, P.K.: "Tribological Properties of Ceramic/Ti₃Al-Nb Sliding Couples to 700°C," presented at ICMC, San Diego, CA, April 1989, NASA TM 102401. Surface and Coatings Technology, 43/44 (1990) 663-673.
10. Sliney, H.E., DellaCorte, Christopher, and Deadmore, D.L.: "Quality Control of the Tribological Coating - PS212," NASA TM 102067, 1989.
11. DellaCorte, Christopher, and Sliney, H.E.: "Tribological Properties of PM212: A High Temperature Self-Lubricating, Powder Metallurgy Composite," NASA TM-102355, STLE Preprint 90-AM-4E-4, Lubrication Engineering, 47 (4) 298-303.
12. DellaCorte, Christopher and Farmer, S. C.: "Experimentally Determined Wear Behavior of an Al₂O₃-SiC Composite from 25 to 1200°C," Tribology of Composite, NASA TM 102549, edited by P.K. Rohatgi, P.J. Vlau and C.S. Yust, ASM International, Metals Park, Ohio, 1990 pp. 345-354.

13. Bonham, C. D. and DellaCorte, Christopher: "Computerized Data Acquisition for Tribological Tests," presented at STLE Annual Meeting, May 1989, Denver, CO, NASA TM 102508. STLE, Vol. 47, 11, 907-923, 1990.
14. Sliney H. E. and DellaCorte, Christopher: "A Test Machine for Measuring Friction and Wear in Controlled Atmospheres to 1200°C," presented at STLE Annual Meeting, Denver, Colorado, 1989, NASA TM 102405. STLE, Vol. 47, 4, 314-319, 1990.
15. DellaCorte, Christopher: "The Experimental Evaluation and Application of High Temperature Solid Lubricants," Case Western Reserve University, Ph.D. Thesis and NASA TM 102476, 1989. DOE Report #50162-3.
16. Steinetz, B.M., DellaCorte, Christopher, and Tong, M.: "Seal Concept and Material Performance Evaluation for the NASP Engine," Paper No. 60, presented at the 7th NASP Technology Symposium, Cleveland, Ohio, October 1989.
17. Steinetz, B. M., DellaCorte, Christopher, and Tong, M., "High Temperature NASP Engine Seals: A Technology Review," NASA TM 014468, August 1991.
18. DellaCorte, Christopher, Sliney, H. E., and Bogdanski, M., "Tribological and Mechanical Comparison of Sintered and HIPped PM212: High Temperature Self-Lubricating Composites," Prepared for the Annual Meeting of the Society of Tribologists and Lubrication Engineers, Philadelphia, Pennsylvania, May 4-7, 1992, NASA TM 105379, 1991. STLE Preprint 92-AM-6D-2.
19. DellaCorte, Christopher and Steinetz, B., "Relative Sliding Durability of Two Candidate High Temperature Oxide Fiber Seal Materials," NASA TM 105199, September 1991. J. of Propulsion and Power, Vol. 9, No. 2, March-April 1993, pp. 307-312.
20. Farmer, S. C., Book, P. O., and DellaCorte, Christopher, "Sliding Wear of Self-Mated Al₂O₃-SiC Whisker Reinforced Composites at 23-1200°C," NASA TM 104490, 1991. J. of Materials Science, Vol. 28 (1993), 1147-1154.
21. DellaCorte, Christopher, Pepper, S. V., and Honey, F. S., "Tribological Properties of Ag/Ti Films on Al₂O₃ Ceramic Substrates," Prepared for the International Conference on Metallurgical Coatings and Thin Films sponsored by the American Vacuum Society, San Diego California, April 22-26, 1991, NASA TM 103784, 1991. Surface and Coatings Technology, 52 (1992) 31-37.
22. DellaCorte, Christopher, "An Analysis of the Wear Behavior of SiC Whisker Reinforced Alumina From 25 to 1200°C," NASA TM 104489, 1991. STLE Paper #92-TD-4A-3, October 1992.
23. DellaCorte, Christopher, "Tribological Characteristics of Silicon Carbide Whisker-Reinforced Alumina at Elevated Temperatures," NASA TM 103799, 1991. Also published as Chapter 10 of Friction and Wear of Ceramics, edited by S. Jahanmir; Marcel-Dekker, Inc., 1994, pp. 225-259.

24. Edwards, P. M., Sliney, H. E., DellaCorte, Christopher, Whittenberger, J. D., and Martineau, R. R., "Mechanical Strength and Thermophysical Properties of PM212: A High Temperature Self-Lubricating Powder Metallurgy Composite," DOE/NASA/50162-5, NASA TM-103694, 1990.
25. DellaCorte, Christopher, Steinetz, B., "Tribological Evaluation of a Al₂O₃-SiO₂ Ceramic Fiber Candidate for High Temperature Sliding Seals," NASA TM 105611, April 1992.
26. Steinetz, B. M., DellaCorte, Christopher, Machinchick, M., Mutharasan, R., Du, G-W., Ko, F., Sirocky, P. J., and Miller, J. H., "High Temperature Dynamic Engine Seal Technology Development," Prepared for the National Aerospace Plane Mid-Term Technology Review, Monterey, California, April 20-24, 1992, NASA TM 105641, 1992.
27. DellaCorte, Christopher, Steinetz, B., "Sliding Durability of Two Carbide-Oxide Candidate High Temperature Fiber Seal Materials in Air to 900o C,". NASA TM 105554, April 1993.
28. Bogdanski, M. S., Sliney, H. E., and DellaCorte, Christopher, "Tribological and Microstructural Comparison of Hipped PM212 and PM212/Au Self-Lubricating Composites," DOE/NASA/50306-1, NASA TM-105615, April 1992 (prepared for STLE-ASME Joint Tribology Conf., San Diego, CA, October 18-21, 1992).
29. DellaCorte, Christopher and Steinetz, B., "Relative Sliding Durability of Candidate High Temperature Fiber Seal Materials," NASA TM 105806, August 1992.
30. Steinetz, B. M., DellaCorte, Christopher, Kren, L. A., Sirocky, P. J., "High Temperature Hypersonic Engine Seal Technology Development Solid Seal/Material Evaluation (U)," Prepared for the 1993 National Aero Space Plane Mid-Term Technology Review, Monterey, California, April 13-16, 1993. Paper Number 114. Unclassified.
31. DellaCorte, Christopher, Deadmore, D. L., "Vickers Indentation Hardness of Stoichiometric and Reduced Single Crystal TiO₂ (Rutile) From 25 to 800°C," NASA TM 105959, 1993.
32. Benoy, P. A., DellaCorte, Christopher, "Tribological Characteristics of Sputtered Au/Cr Films on Alumina Substrates at Elevated Temperatures," NASA TM 106078, 1993, and DOE/NASA/50306-3, 1993. Surface and Coatings Technology, 62 (1993) 454-459.
33. Sliney, H. E., DellaCorte, Christopher, "The Friction and Wear of Ceramic/Ceramic and Ceramic/Metal Combinations in Sliding Contact," prepared for the STLE-ASME Tribology Conference sponsored by the Tribologists and Lubricant Engineers, New Orleans, Louisiana, October 24-17, 1993. NASA TM 106348. DOE 50306-3.
34. Bemis, K., Bogdanski, M. S., DellaCorte, Christopher, and Sliney, H. E.: "The Effect of Prolonged Exposure to 750°C Air on the Tribological Performance of PM212," prepared for the STLE Annual Meeting sponsored by the Society of Tribologists and Lubrication Engineers, Pittsburgh, Pennsylvania, May 2-5, 1994. DOE/NASA/50306-4, NASA TM-106472.

35. DellaCorte, Christopher, and Wood, J.C.: "High Temperature Solid Lubrication Materials for Heavy Duty and Advanced Heat Engines," prepared for the 1994 Fall Technical Conference sponsored by the International Combustion Engine Division of the American Society of Mechanical Engineers, LaFayette, Indiana, October 2-5, 1994. DOE/NASA/50306-5, NASA TM-106570.
36. Fellenstein, J.A., and DellaCorte, Christopher: "A New Tribological Test for Candidate Brush Seal Materials Evaluation", prepared for the 1995 STLE annual meeting. NASA TM-106753. October 1994.
37. DellaCorte, Christopher, Lukaszewicz, V., and Steinetz, B. M.: "Static and Dynamic Friction Behavior of Candidate High Temperature Airframe Seal Materials". NASA TM 106571, December 1994.
38. Bogdanski, M.S., Sliney, H.E., and DellaCorte, Christopher: "The Effect of Processing and Compositional Changes on the Tribology of PM212 in Air," presented at the STLE 1993 annual meeting. NASA TM 105945.
39. Sliney, H.E., Loomis, W.R., and DellaCorte, Christopher: "Evaluation of PS212 Coatings Under Boundary Lubrication Conditions with an Ester-Based Oil to 300oC," prepared for the 1995 International Conference on Metallurgical Coatings and Thin Films. NASA TM- 106763.
40. Sliney, H.E., Benoy, P.A., Korenyi-Both, A., and DellaCorte, Christopher: "Tribology and Microstructure of PS212 with a Cr2O3 Seal Coat," NASA TM 106768, December 1994.
41. DellaCorte, Christopher and Steinetz, B. M.: "Sliding Durability of Candidate Seal Fiber Materials in Hydrogen from 25 to 900oC," NASA TM 105939, March 1993.
42. Sliney, H.E., Lukaszewicz, V., and DellaCorte, Christopher: "The Tribology of PS212 Coatings and PM212 Composites for the Lubrication of Titanium 6A1-4V Components of a Stirling Engine Space Power System," prepared for the Annual Meeting sponsored by the Society of Tribologists and Lubrication Engineers, Pittsburgh, Pennsylvania, May 2-5, 1994, NASA TM 106462.
43. Zabinski, J.S., Day, A.E., Donley, M.S., DellaCorte, Christopher, McDevitt, N.T.: "Synthesis and Characterization of a High-Temperature Oxide Lubricant," Chapman & Hall/Journal of Material Science Vol. 29, May 16, 1994, pp. 5875-5879.
44. Benoy, P. A., DellaCorte, Christopher: "Au/Cr Sputter Coating for the Protection of Alumina During Sliding at High Temperatures," prepared for the Joint Tribology Conference sponsored by the Society of Tribologists and Lubrication Engineers and the American Society of Mechanical Engineers, Orlando, Florida, October 8-11, 1995, NASA TM 106853.
45. DellaCorte, Christopher and Edmonds, B.J.: "Preliminary Evaluation of PS300: A New Self-Lubricating High Temperature Composite Coating for Use to 800°C", NASA TM

107056, Prepared for Energy Week Conference and Exhibition cosponsored by API and ASME Houston, Texas, January 29-February 2, 1996.

46. DellaCorte, Christopher: "The Effect of Counterface on the Tribological Performance of a High Temperature Solid Lubricant Composite From 25 to 650°C", prepared for the International Conference on Metallurgical Coatings and Thin Films sponsored by the American Vacuum Society San Diego, California, April 22-26, 1996. NASA TM 107183.
47. DellaCorte, Christopher and Laskowski, J.A.: "Tribological Evaluation of PS300: A New Chrome Oxide Based Solid Lubricant Coatings Sliding Against Al₂O₃ from 25 to 650°C", NASA TM 107163, Presented at the 1996 Joint Tribology Conference.
48. DellaCorte, Christopher: "The Effect of Compositional Tailoring on the Thermal Expansion and Tribological Properties of PS300: A Solid Lubricant Composite Coating", NASA TM 107332, Prepared for the 1997 STLE Annual Meeting. Tribology Transactions, Vol. 40, pp. 639-642, October 1997.
49. Laskowski, J.A. and DellaCorte, Christopher: "Friction and Wear Characteristics of Candidate Foil Bearing Materials from 25°C to 800°C", NASA TM 107082, Lubrication Engineering, Vol. 52, No. 8, pp. 605-612, 1996.
50. Fellenstein, J.A., DellaCorte, Christopher, Moore, K.D. and Boyes, E.: "High Temperature Brush Seal Tuft Testing of Metallic Bristles Versus Chrome Carbide", NASA TM 107238, Presented at the 32nd AIAA Joint Propulsion Conference, July 1996.
51. DellaCorte, Christopher: "A New Foil Air Bearing Test Rig for Use to 700°C and 70,000 rpm", NASA TM 107405, Prepared for the 1997 Tribology Conference cosponsored by the Society of Tribologists and Lubrication Engineers and the American Society of Mechanical Engineers, London, England, UK, September 8-12, 1997. Tribology Transactions, Vol. 41, pp. 335-340, July 1998.
52. Fellenstein, J.A., DellaCorte, Christopher, Moore, K. D. and Boyes, E.: "High Temperature Brush Seal Tuft Testing of Selected Nickel-Chrome and Cobalt-Chrome Superalloys", NASA TM 107497, prepared for the 33rd Joint Propulsion Conference and Exhibit cosponsored by AIAA, ASME, SAE, and ASEE Seattle, Washington, July 6-9, 1997.
53. Fellenstein, J.A. and DellaCorte, Christopher: "Preliminary Tuft Testing of Metallic Bristles Versus PS212, PS300, and HVOF300", NASA TM 107522, June 1998.
54. DellaCorte, Christopher; Fellenstein, J.A. and Benoy, P.A.: "Evaluation of Advanced Solid Lubricant Coatings for Foil Air Bearings Operating at 25 and 500 °C", NASA TM 1998-206619, June 1998. Tribology Transactions, Vol. 42, pp. 338-342, April 1999.
55. DellaCorte, Christopher: "The Evaluation of a Modified Chrome Oxide Based High Temperature Solid Lubricant Coating for Foil Gas Bearings. NASA/TM-1998-208660, October 1998. Tribology Transactions, Vol. 43, Number 2, pp. 257-262, April 2000.

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58. Heshmat, Hooshang; Walton, II, James F.; DellaCorte, Christopher; Valco, Mark: "Oil-Free Turbocharger Demonstration Paves Way to Gas Turbine Engine Applications," presented at the International Gas Turbine & Aeroengine Congress & Exhibition sponsored by the American Society of Mechanical Engineers, Munich, Germany, May 8-11, 2000, 2000-GT-620.
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