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TESIS DOCTORAL

**FISURACION INDUCIDA POR HIDROGENO DE ACEROS
SOLDABLES MICROALEADOS: CARACTERIZACION Y
MODELO DE COMPORTAMIENTO**

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CAPITULO 9

BIBLIOGRAFIA

- [1] H. Chino, M. Abe, K. Katayama, H. Takemiro and H. Akazaki: in *Pipeline Technology Conference*, Oostende, Belgium, 1990, Part A, pp. P.4.1.
- [2] M. Pontremoli and G. Buzzichelli: *Composition, microstructure and properties of pipeline steels with high HIC and SSCC resistance*, BTF Special Issue, 1988, pp. 59-67.
- [3] H. Takemiro and H. Chino: *The progress in pipeline material properties*, Nippon Steel Corporation, April 1991.
- [4] G.M. Pressouyre, R. Blondeau, G. Primon, and L. Cadiou: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 212-218.
- [5] R. Blondeau: *Problems related to use of low alloy steels in H₂S environments: industrial solutions*, Ironmaking and Steelmaking, Vol 18 Nº 3, 1991, pp. 201-210.

- [6] M. Iino, N. Nomura, H. Takezawa and T. Takeda: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 159-167.
- [7] M.L. Bullen, M.J. Humphries and R.D. Merrick: in *Int. Conf. on Interaction of steels with hydrogen in petroleum industry*, Materials Properties Council Paris, Mar. 1989.
- [8] M.J. Humphries, J.E. McLaughlin and R.J. Pargeter: in *Int. Conf. on Interaction of steels with hydrogen in petroleum industry*, Materials Properties Council Paris, Mar. 1989.
- [9] R.T. Hill and M. Iino: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 196-199.
- [10] NACE - MR - 01 - 75. *Sulfide Stress Corrosion Resistant Metallic Materials for Oil Field Equipment*.
- [11] S. Endo, M. Nagae, Y. Kobayashi and K. Ume: *ISIJ Int.*, Vol 34, 1994, pp. 217-223.
- [12] *High-Strength Structural and High-Strength Low-Alloy Steels*, ASM. Metals Handbook, Vol. 1, Tenth Edition , 1990, pp. 388-423.
- [13] *Metals and their weldability*, Welding Handbook, Vol. 4, 7th Edition. American Welding Society, 1982, pp. 24-32.
- [14] P.E. Repas: *Metallurgical Fundamentals for HSLA steels in Microalloyed HSLA steels*, ASTM International, 1988, pp. 5.
- [15] E.E. Fletcher: *High-Strength-Low-Alloy Steels: Status, Solution and Physical Metallurgy*, Batelle Press, 1979.
- [16] G. Gabetta and I. Cole: *Fatigue Fract. Engng. Mater. Struct.*, Vol. 16, No. 6, 1993, pp. 603-618.

- [17] J. Charles, R. Coudreuse, R. Blondeau and L. Cadiou: *Corrosion 90*, paper n° 202, Las Vegas, April 1990, pp.23-27.
- [18] F. Terreur, C. Montfort and J. Defourny: in *Proc. of Int. Conf. on Interaction of Steels with Hydrogen in Petroleum Industry Pressure Vessel Service*, Paris, Mars 1989.
- [19] Y. Kobayashi *et al*: *Corrosion Science*, Vol 27, n° 10/11, 1985, pp. 1117-1135.
- [20] V.S. Davey: *Hydrogen Assisted Cracking of High Strength in the Legs of Jack-Up Rigs*, Third International Conference: The Jack-Up Drilling Platform, Design, Construction and Operation. September 24th and 25th 1991.
- [21] C. Renaudin: *Utilisation des Aciers HLE en Conditions de Protection Cathodique*, Memoire, Conservatoire National des Arts et Metiers, 1994.
- [22] *Hydrogen Assisted Cracking of High Strength Steels immersed in Seawater*, Health and Safety Executive Offshore Division, Interim Guidance Document.
- [23] *Synopses of ECSC contracts in iron and steel research*, Science Research Development, 1986-1993, pp. 476, 479, 483, 490, 494, 495, 497, 503, 508, 511, 512. European Commission, 1995.
- [24] F. Gutiérrez-Solana, J. A. Alvarez, A. M. Brass, J. Chêne, L. Coudreuse, M. A. Astiz, C. Renaudin, J. Belzunce and J.J. Gonzalez: *Stress Corrosion Cracking on Weldable Microalloyed Steels*, ECSC Contract n° 92.F2 11a 7210, Final Report, April 1996.
- [25] F. Gutiérrez-Solana, J.J. Gonzalez, M. V. Biezma, A. M. Brass, M. A. Astiz, J. Chêne and J. M. Varona: *Modelización de la Corrosión Bajo Tensión en aceros de baja aleación*, ECSC Contract n° 7210-SA-901 (F5.7/87)], Final Report, Marzo 1991.
- [26] F. Gutiérrez-Solana, A. Valiente, J.J. González and J.M. Varona: *Metall. Trans. A*, Vol. 27A, 1996 , pp. 291-304.

- [27] D.A. Jones: *Principles and Prevention of Corrosion*, Maxwell and Macmillan Editions, New York, 1992.
- [28] *Environmentally Assisted Cracking: Science and Engineering*, ASTM STP 1049, W.B. Lisagor, T.W. Crooker and B.N. Leis, eds., ASTM, Philadelphia, PA; 1990.
- [29] D. Desjardins et R. Oltra: *Corrosion sous Contrainte, Phénoménologie et Mécanismes*, D. Desjardins et R. Oltra, eds; Les Editions de Physique, Les Ulis, Cedex A, France, 1992; pp 1-17.
- [30] F. Gutiérrez-Solana, C. Takamadate, I.M. Bernstein and A.W. Thompson: *Metall. Trans. A*, vol 18A, 1987, pp. 1023-1028.
- [31] R. Kerr, F. Gutiérrez-Solana, I.M. Bernstein and A.W. Thompson: *Metall. Trans. A*, vol 18A, 1987, pp. 1011-1022.
- [32] J.J. González: Tesis Doctoral, Universidad de Cantabria, 1987.
- [33] R.W. Staehle: *Stress Corrosion Cracking and Embrittlement of Iron Base Alloys*; R.W. Staehle *et al.* eds. NACE 5, NACE, Houston, TX, 1977, p. 180-207.
- [34] R.N. Parkins: in *Proc of 5th Symposium on Line Pipe Research*, Am. Gas Assoc., Airlintong; VA, 1974, p. U1.
- [35] *Stress Corrosion Cracking of Metals - A state of the Art*, ASTM STP 518, H.L. Craig, Jr., ed, ASTM, Philadelphia, PA; 1972.
- [36] W.H. Johnson: in *Proc of the Royal Society*, n° 158, 1875, pp. 168.
- [37] B.D. Craig: *ASM Metals Handbook*, 9th ed. ASM, Metals Park, OH, 1987, vol. 13, pp. 164-166.
- [38] H.G. Nelson, D. P. Williams and A.S. Tetelman: *Metall. Trans.*, vol.2, No. 4, 1971, pp. 953-959.

- [39] R.P. Wei, K. Klier, G.W. Simmons and Y.T. Chou: *Hydrogen Embrittlement and Stress Corrosion Cracking*, Gibala and Hekelman, eds., ASM, Metals Park, OH, 1986, pp. 103-133.
- [40] R. E. Ricker and D. J. Duquette: "The role of environment of time-dependent crack growth", Technical Report. NR 036-093, Office of Naval Research, 1981.
- [41] J.P. Hirth: *Metall. Trans.* 11A, 1980, pp 861-890.
- [42] J.P. Hirth: *Hydrogen Embrittlement and Stress Corrosion Cracking*, R. Gibala and R.F. Hehenam, eds., ASM, Metals Park, OH, 1986, pp. 29-41.
- [43] L. Coudreuse: *Corrosion sous Contrainte, Phénoménologie et Mécanismes*, D. Desjardins et R. Oltra, eds; Les Editions de Physique, Les Ulis, Cedex A, France, 1992; pp 396-423.
- [44] C. Zapffe and C. Sims: *Trans. TMS-AIME*, Vol. 145, 1941, pp. 225-261.
- [45] A.S. Tetelman and W.D. Robertson: *Trans. TMS-AIME*, vol. 224, 1962, pp. 775-783.
- [46] J.R. Tien, A.W. Thompson, I. M. Bernstein and R.J. Richards: *Metall. Trans.*, vol. 7A, 1976, pp. 821-829.
- [47] M.R. Louthan: *Hydrogen in Metals*, American Society for Metals, 1974, p. 53.
- [48] N.J. Petch and P. Stables: *Nature*, vol. 169, 1952, pp. 842-843.
- [49] A.A. Griffith: *The Phenomena of Rupture and Flow in Solids*, Philosophical Transactions of the Royal Society, serie A, vol. 221, 1920, pp. 163-198.
- [50] A.R. Troiano: *Trans. ASM*, vol. 52, 1960, pp. 54-80.
- [51] R.A. Oriani and P.H. Josephic : *Acta. Met.*, vol. 22, 1974, p. 1065.

- [52] R.A. Oriani and P.H. Josephic : *Acta. Met.*, vol. 25, 1977, p. 979.
- [53] W.W. Gerberich, J. Garry and J.F. Lessar: *Effect of Hydrogen on Behaviour of Materials*, A.W. Thompson and I.M. Bernstein ed., TMS-AIME, New York, 1976, p. 70.
- [54] H.P. Van Leeuwen: *Effect of Hydrogen on Behaviour of Materials*, A.W. Thompson and I.M. Bernstein, eds., TMS-AIME, New York, 1976, pp. 480.
- [55] A.W. Thompson: *Effect of Hydrogen on Behaviour of Materials*, A.W. Thompson and I.M. Bernstein, eds., TMS-AIME, New York, 1976, pp. 467.
- [56] J.J. Gilman: *Stress Corrosion Cracking and Embrittlement of Iron Base Alloys*; R.W. Staehle *et al.* eds. NACE 5, NACE , Houston, TX, 1977, p. 193.
- [57] W.Y. Chu, C.M. Hsiao and S.Q. Li: *Scripta Metal*, vol. 13, 1979, pp. 1057.
- [58] C.D. Beachem: *Stress Corrosion Cracking and Embrittlement of Iron Base Alloys*; R.W. Staehle *et al.* eds. NACE 5, NACE, Houston, TX, 1977, p. 376-381.
- [59] P. Bastien et P. Azou: *CR. Acad. Sciences* 232, 1951, pp. 1545-48.
- [60] A.N. Stroh: *Adv. Phys.*, vol. 6, 1957, p.418.
- [61] S.P. Lynch: *Metals Forum*, vol. 2, 1979, p. 1189.
- [62] S. Gahr, M.L. Grossbeck and H.K. Birnbaum: *Acta. Met.*, vol. 25, 1977, p. 125.
- [63] H.K. Birnbaum: *Hydrogen Embrittlement and Stress Corrosion Cracking*, Gibala and Hekelman, eds.,ASM, Metals Park, OH, 1986, pp. 153-177.
- [64] R.H. Jones and R.E. Ricker; "Stress-Corrosion Cracking, Materials Performance and Evaluation" R.H. Jones Ed., ASM, Materials Park, OH, 1992, pp. 1-40.

- [65] F. Gutiérrez-Solana: Tesis Doctoral, Universidad Politécnica de Madrid, 1981.
- [66] R.P. Wei: *Hydrogen Effects in Metals*, I.M. Bernstein and A.W. Thompson eds., AIME, New York, NY, 1981, pp. 677-690.
- [67] R.P. Wei and G.W. Simmons: *Scripta Metall.*, vol. 10, 1976, pp. 153-157.
- [68] C.D. Kim and A.W. Loginow: *Corrosion*, vol. 24 (10), 1968, pp. 313-318.
- [69] J.R. Scully and P.J. Moran: *Corrosion*, vol. 44 (3), 1988, pp. 176-185.
- [70] W.W. Gerberich, Y.T. Chen and C. St. John: *Metall. Trans. A.*, vol. 6A (3), 1975, pp. 1485-1498.
- [71] H.P. van Leeuwen: *Eng. Fract. Mech*, vol. 6, 1974, pp. 141-161.
- [72] H.P. van Leeuwen: *Corrosion*, vol. 31 (3), 1975, pp. 42-50.
- [73] F. Gutiérrez-Solana and I.M. Bernstein: *Fracture Control of Engineering Structures*, 6th Eur. Conf. on Fracture, H.C. Van Elst and A. Bakker eds., EMAS, Warley, West Midlands, U.K., 1986, pp. 1995-2007.
- [74] J. A. Donovan: *Metall. Trans. A.*, vol. 7A, 1976, pp. 145-149.
- [75] M. Kurkela, M. Frankel, R.M. Latanision, S. Suresh and R.O. Ritchie: *Scripta Metall.*, vol. 16, 1982, pp. 455-459.
- [76] J. Albrecht, I.M. Bernstein and A.W. Thompson: *Metall. Trans. A.*, vol. 13A, 1982, pp. 811-820.
- [77] I.M. Bernstein and A.W. Thompson: *Atomistics of Fracture*, R.M. Latanision and J. Pickens eds., Plenum Press, New York, 1983, pp. 813-821.
- [78] C. Hwang: Ph. D. Thesis, Carnegie Mellon University, Pittsburgh, PA, 1984.

- [79] M. Frankel and R.M. Latanision: *Metall. Trans. A.*, vol. 17A, 1986, pp. 869-875.
- [80] S.V. Nair, R.R. Jensen and J.K. Tien: *Metall. Trans. A.*, vol. 14A, 1983, pp. 385-393.
- [81] S.V. Nair and J.K. Tien: *Metall. Trans. A.*, vol. 16A, 1985, pp. 2333-2340.
- [82] S.V. Nair: *Fracture Mechanics: Microstructure and Micromechanisms*, S.V. Nair, J.K. Tien R.C. Bates and O. Buck eds., ASM International, Materials Park, OH, 1990, pp. 169-199.
- [83] C.D. Beachem: *Metal Trans.*, vol. 3, 1972, pp. 437-451.
- [84] N.J. Petch: *Phil. Mag.*, 1956, pp. 331-337.
- [85] D.G. Westlake: *Trans.*, ASM, vol. 62, 1969, pp. 1000-1006.
- [86] R.A. Oriani: *Ann. Rev. Mater. Sci.*, vol. 8, 1978, pp. 327-357.
- [87] R.A. Oriani and P.M. Josephic: *Environment Sensitive Fracture of Engineering Materials*, Z.A. Foroulis, ed., TMS-AIME, Warrendale, PA, 1979, pp. 440-450.
- [88] J.C.M. Li, R.A. Oriani and L.S. Darken: *Z. Phys. Chem.*, vol. 49, 1966, pp. 271-290.
- [89] J. R. Rice: *Stress Corrosion Cracking and Embrittlement of Iron Base Alloys*; R.W. Staehle *et al.* eds. NACE 5, NACE, Houston, TX, 1977, pp. 11-15.
- [90] G.M. Pressouyre: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 18-34.
- [91] J. R. Rice: *Effect of Hydrogen on Behaviour of Materials*, A.W. Thompson and I.M. Bernstein, ed., Wyoming, 1975, pp. 455-466.

- [92] R.P. Messmer and C.L. Briant: *Acta Metall.*, vol. 30, 1982, pp. 457-467.
- [93] T.D. Lee, T. Goldenberg and J.P. Hirth: *Metall. Trans. A*, vol. 10A, 1979, pp. 199-208.
- [94] T.D. Lee, T. Goldenberg and J.P. Hirth: *Metall. Trans. A*, vol. 10A, 1979, pp. 439-448.
- [95] J. Kameda: *Acta Metall.*, vol. 34, 1986, pp. 867-889.
- [96] G.M. Pressouyre and I.M. Bernstein: *Metall. Trans. A*, vol. 9A, 1978, pp. 1571-1580.
- [97] G.M. Pressouyre: *Metall. Trans. A*, vol. 14A, 1983, pp. 2189-2193.
- [98] I.M. Bernstein and A.W. Thompson: *Hydrogen Embrittlement and Stress Corrosion Cracking*, Gibala and Hekelman, eds., ASM, Metals Park, OH, 1986, pp. 135-152.
- [99] A.W. Thompson and J.C. Chesnutt: *Metall. Trans. A*, vol 10A, 1979, pp. 1193-1196.
- [100] J.J. González, F. Gutiérrez-Solana and J.M. Varona: *Metall. Trans. A*, vol. 27A, 1996, pp. 281-290.
- [101] R. Kerr, F. Gutiérrez-Solana, I.M. Bernstein and A.W. Thompson, *Metall. Trans. A*, Vol. 18A, 1987 , pp. 1011-1022.
- [102] F. Gutiérrez-Solana J.J. González, J.M. Varona and M.V. Biezma: *Corr. Sci.*, vol. 35, No. 1-4, 1993, pp. 499-505.
- [103] M.V. Biezma, F. Gutiérrez-Solana, J.J. González, and J.M. Varona: *Anales de Mecánica de la Fractura*, vol. 9, 1992, pp. 193-199.
- [104] H. Yatabe, K. Yamada, E.R. de los Rios and K.S. Miller: *Fatigue Fract. Engng. Mater. Struct.* Vol 18, 1995, pp. 377-384.

- [105] M. Iino, N. Nomura, H. Takezawa and T. Takeda: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 159-167.
- [106] G. Philipponeau, M. Habashi, J. Galland and P. Azou: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 168-172.
- [107] A. Ikeda, A. Nakamura and J. Kushida: in *Int. Conf. on Interaction of Steels with Hydrogen in Petroleum Industry*, Materials Properties Council, Paris, March 1989.
- [108] M.J. Godden, G.J. Biefer, M.I. Shemata and J.D. Boyd: in *Conf. on Inclusions and Residuals in Steels*, Ottawa, March 1985.
- [109] T. Taira, Y. Kobayaski and K. Matsumoto: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 173-180.
- [110] A. Coolen, M. Poupon, B. Lefebvre and Y. Provou: in *Proc. of 1st Int. Conf. on Current Solutions to Hydrogen Problems in Steels*, C.G. Interrante and G.M. Pressouyre, eds., ASM. Metals Park, Ohio, OH, 1982, pp. 186-190.
- [111] Y. Sugitani, S. Yamaguchi, M. Hashino and H. Tomono: in *Int. Conf. of HSLA Steels Technology and Application*, 1984, p. 403.
- [112] M. Margot-Marette, J.C. Charbonnier, L. Coudreuse and J. Charles: in *Int. Conf. on Interaction of Steels with Hydrogen in Petroleum Industry*, Materials Properties Council, Paris, March 1989.
- [113] *ASM Metals Handbook*, 9th ed. ASM, Metals Park, OH, 1987, vol. 13, pp. 245-282.
- [114] D.O. Sprowls: *Stress-Corrosion Cracking, Materials Performance and Evaluation*, R.H. Jones ed., ASM, Materials Park, OH, 1992, pp. 363-415.

- [115] H.L. Logan: *The stress corrosion of metals*, New. York, John Willey and Sons, 1966.
- [116] R.N. Parkins et al.: *Br. Corr. J.*, vol. 7, 1982, pp. 154-167.
- [117] *Metal Corrosion, Erosion and Wear*, Annual Book of ASTM Standards, Section 3, Vol 03.02, ASTM.
- [118] M.B. Shumaker et al: in *Stress Corrosion Testing*, ASTM, STP 425, 1967, pp. 317-341.
- [119] T.P. Hoar and J.M. West: *Nature*, vol 181, 1958, p. 835.
- [120] G.R. Irwin: *Journal of Applied Mechanics*, vol. 24, September 1957, pp.361-364.
- [121] H.R. Smith, D.E. Piper and F.K. Downey: *J. Eng. Fract. Mech.*, vol 1, 1968.
- [122] *Fundamental Aspects of Stress-Corrosion Cracking*, R. W. Staehle, A.J. Forty and D. Van Rooyen, eds., NACE, Houston, TX, 1969.
- [123] *Stress-corrosion Cracking of High Strength Steels and Titanium and Aluminium Alloys*, B.F. Brown, ed., Naval Research Laboratory, Washington DC, 1972.
- [124] S.R. Novak, *Engng. Fract. Mech.*, 5, n°3, 1973.
- [125] U.R. Evans: *An Introduction to metalic corrosion*, 3rd edition, ASM, Metals Park, OH, 1981.
- [126] S. T. Rolfe and J.M. Barsom: *Fracture and Fatigue Control in Structures*, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1977.
- [127] V. Frick, G.R. Janser and J.A. Brown: *Space Shuttle Materials 3*, 1971, pp. 198-220.

- [128] R.P. Jaweti, R.J. Walter, W.T. Chandler and R.P. Frohmbarg; *Hydrogen Environment Embrittlement of Metals*, NASA Tech Survey, NASA CR-2163, Washington, 1973.
- [129] H.R. Gray: *Testing for hydrogen environment embrittlement: Experimental variables in hydrogen embrittlement testing*, ASTM, STP 543, 1974, pp. 133-151.
- [130] J.A. Harris Jr. and M.C. Van Vaderham: *Various mechanical test used to determine the susceptibility of metals to high-pressure hydrogen*, ASTM, STP 543, 1974, pp. 198-220.
- [131] R.J. Walter and W.T. Chandler: *Mater. Sci. Technol.*, vol. 8, 1971, pp. 90-97.
- [132] M. Henthorne and R.N. Parkins; *Corrosion Science*, 6, 1966, pp. 357.
- [133] M. Henthorne and R.N. Parkins; *Br. Corros. J.*, 2, 1967, pp. 186.
- [134] *The Slow Strain Rate Technique*, ASTM, STP 665, G.M. Ugiansky and J.H. Payer, eds., ASTM, Philadelphia, PA, 1974, pp. 133-151.
- [135] *Slow Strain Rate Testing for the Evaluation of Environmentally Induced Cracking*, ASTM STP 1210, R.D. Kane, ed, ASTM, Philadelphia, 1993.
- [136] R.N. Parkins: *Slow Strain Rate Testing for the Evaluation of Environmentally Induced Cracking*, ASTM STP 1210, R.D. Kane, ed, ASTM, Philadelphia, 1993, pp. 7-21.
- [137] R.N. Parkins, G.P. Marsh and J.T. Evans: *Predictive Methods for Assessing Corrosion Damage to BWR Piping and PWR Steam Generators*, H. Okada and R.W. Staehle, eds., National Association of Corrosion Engineers, Houston, 1982, pp. 249-260.
- [138] J. Congleton, T. Shoji and R.N. Parkins: *Corrosion Science*, vol. 25, No. 8/9, 1985, pp. 633-650.

- [139] R.N. Parkins and Y. Suzuki: *Corrosion Science*, vol. 23, No. 6, 1983, pp. 577-599.
- [140] J. Yu, L.J. Xue, Z.J. Zhao, G.X. Chi and R.N. Parkins: *Fatigue and Fracture of Eng. Mat. and Structures*, vol. 12, No. 6, 1989, pp. 481-493.
- [141] P. Albrecht, W.R. Andrews, J.P. Gudas, J.A. Joyce, F.J. Loss, D.E. McCabe, D.W. Schmidt and W.A. Vanm der Sly; *Journal Testing and Evaluation*, 10, 1982, pp. 245.
- [142] T. Shoji *et al.*: *Mechanistic understanding of environmentally assisted cracking of RPV steels in LWR primary coolants*, Report USNRC NUREG / CP-0067, 1986.
- [143] J.T. Evans and R.N. Parkins: *The Application of the J-Integral to Stress Corrosion Cracking* Final Report No. 2043/074. University of Newcastle upon Tyne, 1986.
- [144] W.Dietzel and K.H. Schwalbe: *Slow Strain Rate Testing for the Evaluation of Environmentally Induced Cracking*, ASTM STP 1210, R.D. Kane, ed, ASTM, Philadelphia, 1993, pp. 134-148.
- [145] M.G. Vassilaros, R.L. Juers, M.E. Nathishan and A.K. Vasuderant: *Slow Strain Rate Testing for the Evaluation of Environmentally Induced Cracking*, ASTM STP 1210, R.D. Kane, ed, ASTM, Philadelphia, 1993, pp. 123-133.
- [146] L. Coudreuse: *Application des Critères de Mécanique de la Rupture aux Matériaux Ductiles chargés en Hydrogène*, ECSC Contract n° 7210-KB-322 (91.F2. 02a), Final Report, Mars 1995.
- [147] J.A. Alvarez, G. Méndez, F. Gutiérrez-Solana, I. Gorrochategui y J. Laceur: "Anales de Mecánica de la Fractura", Vol. 11, 1994, pp. 413-419.
- [148] G. Gabetta: in *Proc. of ECF 10-Structural Integrity: Experiments, Models and Applications*, Berlin, Sep. 20-23, 1994, pp. 67-69.

- [149] W. Dietzel: BCR-Project *Development of an SCC test procedure based on rising displacement experiments*, Milan 4-5 September 1997.
- [150] P. Aaltonen and A. Toivonen: CIR Meeting, May 1997, Napa Valley, California, USA.
- [151] ESIS P1-92, "ESIS Recommendations for Determining the Fracture Resistance of Ductile Materials", European Structural Integrity Society, January 1992.
- [152] G.M. Pressouyre: PH. D. Thesis, Carnegie Mellon University, 1997.
- [153] H. Tada, P.C. Paris and G.R. Irwin: *The Stress Analysis of Cracks Handbook*, Del Research Corporation, Hellertown, Pennsylvania, 1973.
- [154] V. Kumar, M.D. German and C.F. Shih: *An Engineering Approach for Elastic-Plastic Fracture Analysis*, General Electric Company, NP-1931, Research Project 1237-1, Topical Report, Schenectady, New York, 1981.
- [155] C.F. Shih: *Mechanics of Crack Growth*, ASTM STP 590, ASTM, Philadelphia, PA, 1976, pp. 3-22.
- [156] C.F. Shih and J.W. Hutchinson: *Transactions of ASME Journal of Engineering Materials and Technology*, Series H, Vol. 98, No. 4, 1976, pp. 289-295.
- [157] R.J. Bucci, P.C. Paris, J.D. Landes and J.R. Rice: *Fracture Toughness*, ASTM STP 514, ASTM, Philadelphia, PA, 1972, pp. 40-69.
- [158] J.R. Rice, P.C. Paris and J.G. Merkle: *Progress in Flaw Growth and Fracture Toughness Testing*, ASTM STP 536, ASTM, Philadelphia, PA, 1973, pp. 231-245.
- [159] D.P. Rooke and J.C. Cartwright: *Compendium of Stress Intensity Factors*, Her Majesty's Stationery Office, London, 1976.

- [160] N.L. Goldman and J.W. Hutchinson: *International Journal of Solids and Structures*, Vol. 11, 1975, pp. 575-591.
- [161] A. Needleman and C.F. Shih: *Computer Methods in Applied Mechanics and Engineering*, 1978, pp. 223-240.
- [162] C.F. Shih and V. Kumar: *Estimation Technique for the Prediction of Elastic-Plastic Fracture of Structural Components of Nuclear Systems*, 1st Semiannual Report to EPRI, Contract No. RP1237-1, General Electric Company, Schenectady, New York, 1979.
- [163] V. Kumar, M.D. German and C.F. Shih: *Estimation Technique for the Prediction of Elastic-Plastic Fracture of Structural Components of Nuclear Systems*, Combined 2nd and 3rd Semiannual Report to EPRI, Contract No. RP1237-1, General Electric Company, Schenectady, New York, 1979, 1980.
- [164] V. Kumar, W.G. deLorenzi, W.R. Andrews, C.F. Shih, M.D. German and D.F. Mowbray: *Estimation Technique for the Prediction of Elastic-Plastic Fracture of Structural Components of Nuclear Systems*, 4th Semiannual Report to EPRI, Contract No. RP1237-1, General Electric Company, Schenectady, New York, 1981.
- [165] A.A. Ilyushin: *Prikadnaia Matematika i Mekhanika, P.M.M.*, Vol. 10, 1946, pp. 347.
- [166] V. Kumar, M.D. German, W.W. Wilkening, W.R. Andrews, H.G. deLorenzi and D.F. Mowbray: *Advances in Elastic-Plastic Fracture Analysis*, General Electric Company, NP-3607, Research Project 1237-1, Final Report, Schenectady, New York, 1984.
- [167] A. Zahoor: *Ductile Fracture Handbook*, Vol. 1-3, NP-6301-D/N14, Electric Power Research Institute, Palo Alto, CA, 1989, 1990, 1991.
- [168] C.F. Shih: *Journal of the Mechanics and Physics of Solid*, 29, 1981, pp. 305-326.

- [169] C.F. Shih, M.D. German and V. Kumar: *International Journal of Pressure Vessel and Piping*, 9, 1981, pp. 1-20.
- [170] M.D. German, W.R. Andrews, V. Kumar, C.F. Shih, H.G. deLorenzi and D.F. Mowbray: *Elastic-Plastic Fracture Analysis of Flawed Stainless Steel Pipes*, General Electric Company, NP-2608-LD, Research Project T118-8, Final Report, Schenectady, New York, 1982.
- [171] J.G. Merkle and H.T. Corten: *Journal of Pressure Vessel and Technology Trans. ASME*, Vol 96, 1974, pp. 286-292.
- [172] M.F. Kanninen and C.H. Popelar: "Advanced Fracture Mechanics", Oxford University Press, New York, Engineering Science Series 15, 1974.
- [173] F. Gutiérrez-Solana, M.A. Astiz y M. Elices: *Anales de Ingeniería Mecánica* 1, 1983, pp. 57-62.
- [174] ASTM E813, "Standard Test Method for J_{IC} , a Measure of Fracture Toughness", Annual Book of ASTM Standards, Vol. 03.01, 1997.
- [175] B.F. Brown, "Stress Corrosion Cracking in High Strength Steels and in Titanium and aluminium Alloys", Naval Research Laboratory, 1972.
- [176] ESIS P2-92, "ESIS Recomendations for Determining the Fracture Behaviour of Materials", European Structural Integrity Society, January 1992.
- [177] F. Gutiérrez-Solana, J. González, J.M. Varona and M.V. Biezma: in *Proc. of ECF 10-Structural Integrity: Experiments, Models and Applications*, Berlin, Sep. 20-23, 1994, pp. 659-668.
- [178] A.W. Thompson and I.M. Bernstein: "Advances in Corrosion Science and Technology", Fontana and Stachle, eds. vol. 7, Plenum, NY, 1980, p. 53.
- [179] J.W. Kennedy and J.A. Whittaker: *Corrosion Sci.*, 1968, vol. 8, p. 359.

- [180] M.R. Louthan, J.A. Donovan and D.E. Rawl: *Corrosion*, 1973, vol. 29, p. 108.
- [181] W.W. Gerberich: "Hydrogen in Metals", Bernstein and Thompson, eds., ASM, Metals Park, Ohio, 1974, p. 115.
- [182] M.O. Speidel: "Hydrogen in Metals", Bernstein and Thompson, eds., ASM, Metals Park, Ohio, 1974, p. 575.
- [183] A.W. Thompson and I.M. Bernstein: *Rev. Coating Corrosion*, 1975, vol. 2, p. 3.
- [184] D.P. Williams and H.W. Nelson: *Metall. Trans.*, 1972, vol. 3, p. 2107.
- [185] M.O. Speidel: "Theory of Stress Corrosion Cracking in Alloys", J.C. Scully, ed., NATO, Bruselas, 1971, p. 289.
- [186] P.G. Marsh and W.W. Gerberich: *SCC. Materials Performance and Evaluation*, ISCC, R.H. Hones ed., ASM Materials Park, OH 1992, pp. 63-90.
- [187] J.R. Rice and M.A. Johnson: in *Elastic Behaviour os Solids*, M.F. Kanninen, W.G. Adleer, A.R. Rosenfield and R.I. Jaffee eds., Mac Graw Hill, NY 1970, pp. 641-672.
- [188] J.W. Hutchinson: *J. Mech. Phys. Solids*, 1968, Vol. 16, pp. 13-31.
- [189] J.R. Rice and G.R. Ronsengren: *J. Mech. Phys. Solids*, 1968, Vol. 16, pp. 1-12.
- [190] W.W. Gerberich, T. Livne, X.F. Chen and M. Kaczorowski: *Metall. Trans. A*, 1988, Vol. 19A, pp. 1319-1334.
- [191] W.W. Gerberich: "Fracture Mechanics": *Microstructure and Micromechanisms*, S.V. Nair, J.K. Tien, R.C. Bates and O. Buck eds. ASM International, Materials Park, Ohio1990, pp. 1201.228.

- [192] C.M. Sellars: *Quantitative Metallography*, Master Course on Physical and Mechanical Metallurgie, E.T.S. Ing. Industriales, San Sebastián, Spain 1981.
- [193] L. Sánchez: Tesis Doctoral, Universidad de Cantabria, Santander, 1996.
- [194] J.M. Alegre, L. Sánchez, F. Gutiérrez-Solana: "Anales de Mecánica de la Fractura", Vol. 15, 1998, pp. 73-78.