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BEHIND THE BULLETIN

WRC Contributions Paved the Way for API 579-1/ASME FFS-1

This installment written by David Osage, President and Principal Engineer at Equity.

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Editor's Note: Engineers are often responsible for maintaining the integrity of pressure vessels operating under increasingly demanding conditions. The combination of aging infrastructure and damage mechanisms such as corrosion, creep, and fatigue challenges the safety, reliability, and economic performance of these critical assets. Addressing these issues requires technically sound assessment methods grounded in rigorous research. For decades, the [Welding Research Council, Inc.](#) (WRC) has provided this foundation through its sustained contributions to the development of engineering codes and standards.

Since its formation in 1933, the WRC has served as a unique collaborator across industry, academia, and regulatory bodies. Its primary publication, the WRC Bulletin, has become a cornerstone for knowledge transfer in pressure equipment technology. Through the coordinated efforts of its affiliated groups, the WRC has made significant contributions to the ASME Boiler and Pressure Vessel Code and API standards by advancing test methods, expanding material property databases, and establishing structural assessment procedures that continue to shape engineering practice.

This new *Inspectioning Journal* column will fulfill two objectives: to preserve critical engineering knowledge for the next generation and to highlight the key technical contributions found within 70+ years of WRC Bulletins that may be forgotten or overlooked today. These Bulletins contain decades of collaborative research and development that continue to influence code committees, inspection practices, and equipment integrity assessments worldwide.

Introduction

The inaugural article in this new column focuses on the WRC's central role in the evolution of API 579-1/ASME FFS-1, the international standard for fitness-for-service (FFS) assessment. Initially published in 2000 as a Recommended Practice (RP), this document has matured through four major editions. In 2021, it was recognized as a formal API/ASME International Code, reflecting its global acceptance and technical rigor. WRC-sponsored research has provided the technical justification and methodology behind nearly every part of this standard, including the work now underway to support its planned 2026 edition.

By revisiting the origin and progression of this important standard and by highlighting the foundational Bulletins and contributors behind it, we aim to reinforce the importance of knowledge continuity. This effort is not only a retrospective—it is also an invitation to engage with the legacy that has shaped current practice and will continue to define future advancements.

The WRC Ecosystem: A Catalyst for Industry Advancement

The WRC was established as a collaborative forum to advance welding and pressure equipment technology for the refining, petrochemical, and power generation industries. From its inception, it has operated as a neutral, nonprofit platform that unites industry, academia, and national laboratories to address challenges involving material performance, structural integrity, and equipment safety. Early research on welding processes and metallurgy proved essential in facilitating the shift from riveted to welded construction. This work led to significant improvements across multiple industries, including enhanced reliability, reduced weight, and the adoption of innovative design approaches that continue to influence engineering practice.

Over time, what began as a single council evolved into a broad technical ecosystem. This structure includes a network of specialized councils that guide strategy, working groups that focus on practical implementation, and long-term research initiatives that address emerging challenges.

At the center of this framework is the Pressure Vessel Research Council (PVRC). It serves as the engineering core of the WRC, coordinating expert task groups that investigate key issues affecting pressure-retaining equipment. These include the principles of sound mechanical design, the refinement of fabrication techniques, and the evaluation of equipment performance under service conditions.

In 1966, the WRC expanded its scope by forming the Materials Properties Council (MPC). Its initial mission was to generate reliable mechanical property data for engineering alloys used in demanding applications. Over time, the MPC broadened its focus to encompass additional material categories. These now include high-performance polymers, fiber-reinforced composites, and complex material systems used in advanced manufacturing and extreme service environments.

To support this expanding body of work, the MPC established Joint Industry Projects (JIPs) that bring together stakeholders from industry, academia, and regulatory agencies to collaborate on developing shared technical solutions.

This layered and adaptive structure allowed the WRC to function as more than a single council, supporting the development of technically defensible procedures used throughout the ASME Boiler and Pressure Vessel Code and API standards. The

collaborative efforts have yielded over 600 WRC Bulletins, documenting pioneering research in fatigue, fracture mechanics, creep, inspection, and structural assessment.

In 2010, recognizing the operational efficiencies of integration, the WRC and MPC were formally merged into a unified 501(c)(3) nonprofit organization with a consolidated Board of Directors. This strategic realignment enhanced governance, simplified administrative functions, such as accounting and audits, and strengthened the organization's ability to deliver timely, high-value research aligned with evolving code requirements.

Today, the WRC continues to operate as a self-sustaining model, ensuring that all research is industry-driven, independent, and strategically focused. All revenue from Bulletin sales is reinvested directly into new technology development and supports essential administrative functions. Each Bulletin issued is both a product of the ecosystem and a contribution to future projects, standards development, and professional practice.

The enduring value of the WRC lies not only in its historical contributions, but also in its ability to continuously regenerate technical capability across disciplines. It is a living, evolving ecosystem that preserves institutional knowledge while adapting to new challenges and informing the standards that govern industrial safety and performance worldwide.

Building a Foundation for Jurisdictional Acceptance: The Birth of Fitness-For-Service (FFS)

By the early 1990s, several industrial processing sectors faced a serious reliability challenge: equipment originally designed for 20 to 30 years of service was now operating well beyond its intended design life. Degradation mechanisms such as corrosion, hydrogen-induced cracking (HIC), creep, and fatigue were manifesting more frequently and with increasing severity. Conventional design codes offered no practical guidance for evaluating flaws in service, and in their absence, plant operators relied on inconsistent and often undocumented fitness assessments. As a result, concern grew among regulators, insurers, and operators regarding both safety and asset availability.

In response, the MPC launched a JIP in the mid-1990s to develop a consensus-based FFS methodology. This initiative, originally supported by 45 participating companies, including owner-operators, manufacturers, engineering firms, and laboratories, quickly became one of the most comprehensive collaborative efforts ever undertaken under the WRC umbrella. Although subsequent industry consolidation reduced the active membership to approximately 15 organizations, the technical depth of the group remained strong and representative of the industry. The JIP's central objective was to establish a technically sound and publicly documented FFS framework that could gain jurisdictional acceptance.

At the time, several companies were promoting proprietary, closed-form FFS tools. However, these so-called "black-box" solutions lacked transparency and were routinely rejected by local

jurisdictions and regulatory authorities. The JIP recognized that broad acceptance would require complete public documentation of all methods, assumptions, and validation efforts. Without transparency and traceability, the engineering community would not achieve the credibility needed to support regulatory use.

The flagship deliverable from the JIP was the FFS-25 consultant's report, which synthesized the best available technology and industry practices of the time. This document was subsequently formalized and published as WRC Bulletin 547, titled *Fitness-For-Service Evaluation Procedures for Operating Pressure Vessels, Tanks, and Piping in Refinery and Chemical Service*. Bulletin 547 represented the first unified and publicly vetted FFS procedure, serving as the technical foundation for what would become API Recommended Practice 579, first issued in 2000.

In addition to documenting assessment procedures, the JIP also recognized a critical gap in the formal classification of damage mechanisms—a prerequisite for any defensible FFS evaluation. JIP participants shared the belief that if degradation mechanisms could be reliably identified, then suitable engineering procedures could be developed to evaluate structural integrity in a safe and consistent manner.

This insight led to the initiation of a separate MPC project focused entirely on damage mechanism classification. That effort was funded jointly by API, the National Board Inspection Code (NBIC), and the American Forest & Paper Association (AF&PA). It resulted in a series of technical documents that remain foundational:

- **WRC Bulletin 488:** Damage Mechanisms Affecting Fixed Equipment in the Refining Industry: Carbon and Low-Alloy Steels
- **WRC Bulletin 489:** Damage Mechanisms Affecting Fixed Equipment in the Refining Industry: Austenitic Stainless Steels
- **WRC Bulletin 490:** Damage Mechanisms Affecting Fixed Equipment in the Refining Industry: Dissimilar Metal Welds, Weldments, and High-Temperature Components

This body of work was ultimately consolidated into API Recommended Practice 571, *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*, which continues to serve as a core reference for inspection planning and FFS evaluations.

The development of WRC 547, the JIP's emphasis on transparency, and the foundational work on damage mechanisms collectively provided a structured, jurisdictionally credible alternative to legacy design codes. This effort laid the groundwork for a public domain, technically defensible FFS methodology that could be universally adopted and would evolve into API 579-1/ASME FFS-1.

Technical Evolution through Four Editions: The Development Path of API 579-1/ASME FFS-1

The development of API 579-1/ASME FFS-1 is a case study in collaborative standardization. Following the initial publication of API

RP 579 in 2000, discussions began within ASME to publish a separate FFS document under its Post-Construction Code. The plan at the time was for API 579 to address refining, petrochemical, and chemical facilities, while the ASME version would focus on fossil utility, pulp and paper, and general industrial sectors. However, many members of the ASME Post-Construction Committee (PCC) expressed concern that two separate documents would introduce unnecessary complexity, increase maintenance costs, and, most importantly, risk jurisdictional confusion and non-acceptance.

To address these concerns, API and ASME negotiated the development of a single, unified document—API 579-1/ASME FFS-1—to be maintained by a new Joint API/ASME FFS Committee, the only joint technical standards committee currently operating between the two organizations. Although the joint structure presents challenges, the advantages of international harmonization and regulatory clarity have proven more important than the inefficiencies. Since its establishment in 2001, the committee has operated under a principle of technical consensus and public transparency, informed by global benchmarking efforts such as the Pipeline Defect Assessment Manual (PDAM) and aligned wherever possible with emerging best practices worldwide.

Each subsequent edition of the standard has built on this foundation by incorporating new technology and industry feedback. The majority of technical advancements were enabled by research conducted under the WRC and documented through a series of Bulletins that served as the primary input for revisions and new Parts.

2000 Edition: Launching a Standardized FFS Framework

The First Edition of API 579 was published in 2000 as a Recommended Practice. It established a public domain FFS framework based on the technical work documented in WRC Bulletin 547, which synthesized the work of the MPC-led FFS JIP (FFS-25) and defined engineering procedures for evaluating brittle fracture, metal loss (general and localized), hydrogen damage (blistering, HIC, and SOHIC), crack-like flaws, fire damage, weld misalignment, and shell distortions.

2007 Edition: Establishing a Joint API/ASME Standard

The Second Edition, published as API 579-1/ASME FFS-1, was the first jointly developed document under the new committee. It reorganized the standard into 13 Parts, introducing new procedures and enhanced coverage, most notably the addition of Part 10 for creep damage assessment. Supporting Bulletins included:

- **WRC Bulletin 430** — Reviewed global FFS criteria for crack-like flaws, forming the basis for Part 9 using linear elastic fracture mechanics (LEFM) principles.
- **WRC Bulletin 465** — Developed evaluation methods for erosion, corrosion, pitting, and blisters, enhancing Parts 4–7 and 12 through finite element analysis (FEA) validations.
- **WRC Bulletin 471** — Compiled stress intensity factor (SIF) solutions for surface and embedded cracks, enabling precise crack growth modeling in Part 9.
- **WRC Bulletin 476** — Provided residual stress models for

welded joints and through-wall cracks, essential for accurate crack assessment in Parts 9 and 13.

- **WRC Bulletin 505** — Validated LTA procedures using benchmarking studies, supporting Parts 4 and 5.

2016 Edition: Enhancing Modularity and Fatigue Assessment

The Third Edition introduced a modular structure with 14 Parts and significant advancements in fatigue assessment, hydrogen damage modeling, and creep-fatigue interaction. New supporting Bulletins included:

- **WRC Bulletin 474** — Introduced the Master S-N Curve method for fatigue evaluation of welded components (Part 14).
- **WRC Bulletin 523** — Provided implementation details of the Master S-N Curve method for ASME Section VIII, Division 2 and API 579-1/ASME FFS-1.
- **WRC Bulletin 531** — Detailed hydrogen damage mechanisms, integrating metallurgical and inspection data into Part 7.
- **WRC Bulletin 550** — Standardized strain-life fatigue evaluation, validated by cyclic loading tests, supporting Part 14.
- **WRC Bulletin 554** — Validated stress ranges for the MPC Omega creep model and WRC 541's rupture model, enhancing Part 10.
- **WRC Bulletin 575** — Revisited the Bree Diagram using temperature-dependent material properties.
- **WRC Bulletin 577** — Analyzed constraint effects on fracture toughness near the ductile-brittle transition, supporting Part 9.
- **WRC Bulletin 584** — Provided inspection guidance aligned with the FFS methodology across all Parts.

2021 Edition: Global Harmonization and Alignment with PDAM

The standard's role as a global FFS benchmark was cemented with the publication of its Fourth Edition. While many structural features from the 2016 Edition remained, several important enhancements were made:

- **WRC Bulletin 562: Minimum Pressurization Temperature (MPT) Procedures, Second Edition** — Updated methods for determining fracture toughness based on ASME exemption curve category and other inputs used for determining the minimum allowable temperature (MAT) or MPT. Note that this revision illustrates the WRC's model of continuously updating Bulletins in response to new technical advancements. Once an Edition is complete, Bulletins such as WRC 562 are provided directly to the Joint Committee for consideration and inclusion in future editions of the code.
- **WRC Bulletin 565: Development of New Part 10 Level 1 Screening Curves for API 579-1/ASME FFS-1 (In Preparation)** — Covered the

development of new Level 1 creep screening curves for Part 10, which include both time-dependent and time-independent behavior.

- **PDAM: Pipeline Defect Analysis Manual** — The Level 1 and Level 2 procedures in Part 12 were updated to reflect greater international alignment, particularly with the PDAM. Applicability limits and acceptance criteria were revised based on global experience to ensure FFS assessments remain consistent with current international best practices when technically justified. While the PDAM is not technically a WRC Bulletin, it is a respected and widely used resource. The Joint API/ASME FFS Committee remains committed to incorporating the best available technology, regardless of origin, when it is well-documented, validated, and already in use across the industry. Not every advancement must originate within the WRC; rather, the committee recognizes the value of avoiding duplication and drawing from established, high-quality technical sources wherever possible.

Future (2026) Edition: Expanding Scope with New Damage Mechanisms

Development of the Fifth Edition of API 579-1/ASME FFS-1 is currently underway, with publication targeted for 2026. This revision will introduce several new Parts and enhanced assessment procedures based on recent WRC-sponsored research. The additions address key gaps identified through field experience, industry feedback, and evolving analytical capabilities. Notably, a new Part 15 will address piping vibration, a common and often under-analyzed degradation mechanism in industrial systems. The following WRC Bulletins form the technical basis for many of the planned updates:

- **WRC Bulletin 549: Procedures for Weld Misalignment and Shell Distortions** — Provides updated Rb solutions in Part 8 for evaluating weld misalignment and geometric discontinuities, improving reliability of assessments involving local discontinuities.
- **WRC Bulletin 581: Residual Stress for Crack Growth Modeling** — Supplies alternative residual stress solutions for Annex 9D, derived from FEA and experimental benchmarking, enabling more accurate crack-like flaw assessments in Part 9.
- **WRC Bulletin 590: Constraint Effects in Fracture Resistance** — Quantifies the influence of constraint on fracture toughness for arbitrary stress distributions and serves as the technical foundation for updates to Annex 9I.
- **WRC Bulletin 599: Brittle Fracture Assessment Basis for Annex 3B** — Provides updated screening criteria and reference models to improve the brittle fracture evaluation methodology in Annex 3B.
- **WRC Bulletin 601: Assessment of Existing Fiber Reinforced Polymer Equipment for Structural Damage** — This Bulletin addresses the evaluation of structural damage in fiber-reinforced polymer (FRP) equipment, which presents failure modes and degradation mechanisms that differ

fundamentally from those found in metallic systems. FRP is widely used in the refining and chemical industries due to its corrosion resistance; however, current FFS standards, including API 579-1/ASME FFS-1, do not contain provisions for non-metallic materials. This publication provides technical background developed from over two decades of field application and offers recommendations for extending FFS methodologies to FRP equipment.

- **WRC Bulletin 602: Benchmarking Weld Residual Stress Predictions** — Offers an independent review and technical commentary on the residual stress solutions proposed in WRC 581, validating and clarifying their use in flaw assessments.
- **WRC Bulletin 608: Distortion Due to Fabrication and Welding** — Evaluates fabrication-induced distortions in pressure equipment using nonlinear FEA, intended to support guidance in Part 8 by reference.
- **WRC Bulletin 609: Piping Vibration Screening and Assessment** — Establishes methodologies using dynamic FEA for evaluating piping vibration, forming the technical basis for the new Part 15. This new Part represents a significant addition to API 579-1/ASME FFS-1, addressing a pervasive and complex problem in industrial facilities using state-of-the-art analytical tools.
- **WRC Bulletin 610: Structural Strain Fatigue Evaluation Method** — Introduces a strain-based fatigue damage model for welded joints using nonlinear FEA, advancing the accuracy and conservatism of fatigue assessments in Part 14.
- **WRC Bulletin 613: Corrosion Damage Assessment Using Plausible Profiles (Psqr)** — Validates a statistical and FEA-based methodology for characterizing irregular corrosion patterns, enhancing the rigor and defensibility of evaluations in Parts 4 and 5, with special applicability to pipeline systems.
- **WRC Bulletin 616: Reference Stress Solutions for Crack-Like Flaws** — Provides new elastic-plastic reference stress solutions to support improved flaw stability modeling in Part 9, forming the basis for a planned update to Annex 9C.
- **WRC Bulletin 617: J-Integral Methodologies for Flaw Evaluation** — Implements advanced fracture mechanics procedures based on J-integral techniques for flaw stability evaluation, supporting future enhancements to the crack assessment procedures in Part 9.

These Bulletins reflect the WRC's continued role in generating high-fidelity engineering data and methods, with direct application to national and international standards. As with previous editions, the 2026 update will rely on public domain, peer-reviewed research to ensure transparency, consistency, and jurisdictional acceptance.

Honoring the Pioneers: Engineering Legacies That Endure

The success and credibility of API 579-1/ASME FFS-1 are built not

only on rigorous technical development but on the foundational contributions of individuals whose vision and expertise helped shape the field of FFS. In the September/October 2024 issue of *Inspection Engineering Journal*, I authored the article “[Materials Subject Matter Experts Who Made a Difference: Legacies We Must Not Forget](#),” which explored the lasting impact of several pioneering figures in our industry. Among those highlighted were three individuals whose work was instrumental to the development of the standard:

- Dr. Martin Prager — As the longtime leader of the MPC, Dr. Prager championed interdisciplinary collaboration, particularly in areas involving creep and hydrogen damage. His leadership helped define Parts 4, 5, and 10 of the FFS standard, ensuring that the procedures reflected both metallurgical fidelity and practical implementation. Dr. Prager’s influence also extended to the project structuring and publication strategy, which ultimately led to jurisdictional acceptance.
- Dr. Carl Lundin — A respected technical authority within both ASME and the WRC, Dr. Lundin made significant contributions to the understanding of weldment behavior, elevated temperature strength, and structural discontinuities. He authored and reviewed numerous WRC Bulletins, mentored emerging code developers, and consistently advocated for clarity, conservatism, and public domain transparency in FFS methodologies.
- Dr. Howard Voorhees — Known for his seminal work on time-dependent material behavior, Dr. Voorhees compiled and interpreted stress relaxation data used to characterize creep in high-temperature service. His work on *ASTM DS-60* and subsequent WRC-sponsored research remains critical to long-term performance modeling and is directly cited in FFS creep assessment procedures.

These individuals exemplify the WRC’s long-standing commitment to blending scientific rigor with practical engineering application. Their work not only advanced the technical basis for FFS assessments but also laid the groundwork for the next generation of engineers, researchers, and standards developers to build upon. As we look forward, it is essential that we continue to recognize and preserve these legacies, not merely as a tribute to the past, but as a guide for future innovation. In future articles, additional pioneers who contributed significantly to the WRC ecosystem will be recognized, ensuring their impacts are not lost to time.

Why It Matters

The continued development of API 579-1/ASME FFS-1 is not just a technical exercise—it is an essential effort to extend the safe, reliable operation of critical infrastructure across industries. As more equipment operates well beyond its original design life, the role of FFS methodology becomes central to sound engineering judgment, risk management, and operational continuity.

At the heart of this effort lies the WRC and its Bulletins, which

serve as the technical bridge between innovation and accepted practice. These Bulletins provide the transparent, peer-reviewed documentation that regulators trust, engineers rely on, and standards bodies reference. They are indispensable to gaining jurisdictional acceptance for advanced assessment technologies—from strain-based fatigue and hydrogen damage modeling to fracture mechanics and residual stress evaluations.

Beyond their technical value, each Bulletin preserves institutional knowledge, creating a durable, public-domain paper trail that documents the assumptions, data, and consensus behind the evolution of engineering methodologies. This ensures that progress is not only validated but also transferable to the next generation of practitioners and code developers.

Ultimately, the legacy and future of the WRC’s contributions to FFS standards must be sustained, as this work safeguards more than just compliance—it protects lives, assets, and the continuity of engineering expertise.

Impact and Legacy

The development and global acceptance of API 579-1/ASME FFS-1 stand as a model for how technically sound, transparently documented engineering practices can transform an industry. What began as an effort to organize best practices and address jurisdictional barriers has evolved into an international code used daily to make critical run-or-repair decisions for pressure equipment in nearly every industrial sector.

The WRC, through the coordinated efforts of the MPC, the PVRC, and its extensive network of technical experts, has provided the foundational data, models, and methodologies that underpin the standard. More than 30 WRC Bulletins have directly contributed to its structure and credibility, enabling the standard to withstand regulatory scrutiny, technological change, and expanding service demands.

Not only is the legacy of this work reflected in the procedures found in the standard, but it is also embedded in the very process that developed them: industry-funded, peer-reviewed, and made fully available in the public domain. This model of collaborative technical development continues to serve as a benchmark for advancing code and standard practices across ASME, API, and beyond.

Looking Ahead

This article is the first in a series dedicated to preserving and disseminating the foundational knowledge developed through the WRC ecosystem. In future installments, we will explore additional technical contributions that have shaped API and ASME codes and standards, as well as emerging areas where new research is redefining accepted practices.

Several forthcoming articles will spotlight WRC Bulletins that address high-priority topics across industries:

- **WRC Bulletin 599: Brittle Fracture Assessment Basis for Annex 3B** — This work, led by Brian Macejko, provides critical updates to brittle fracture screening methods and continues

to support regulatory acceptance of low-temperature startup assessments.

- **WRC Bulletin 601:** *Fitness-For-Service Assessments for Non-Metallic Tanks* — Authored by Geoff Clarkson and the UTComp team, this represents a significant expansion of FFS methodology into non-metallic systems, which are increasingly used in corrosive and specialty chemical environments. This Bulletin introduces new material models, failure modes, and inspection considerations not addressed in traditional metal-based approaches.
- **WRC Bulletin 581:** *Residual Stress for Crack Growth Modeling* and **WRC Bulletin 602:** *Residual Stress for Crack Growth Modeling* — Developed by a team including Z. Jin, S. Song, P. Dong from the University of Michigan Welded Structures Laboratory and D.A. Osage, D. Spring, T. Calko, N. Libertowski, R. Patadia of The Equity Technology Group, these Bulletins address residual stresses through a combined experimental and analytical approach, providing new solutions and modeling strategies now being adopted by reference in Annex 9D of API 579-1/ASME FFS-1.

These topics, along with others to follow, reflect the evolving technical challenges facing plant operators, inspectors, and engineers. From brittle fracture to non-metallic system integrity, and from advanced fracture modeling to next-generation fatigue evaluation, the WRC continues to deliver the tools and knowledge needed to meet industry's most demanding requirements.

The purpose of this column is not simply to document the past, but to ensure that knowledge—hard-won and often overlooked—is preserved, understood, and applied. As these articles progress, we will continue to elevate the contributions that have shaped modern engineering practice, while preparing the next generation to carry that work forward. ■

For more information on this subject or the author, please email us at inquiries@inspectioneering.com.



About the Author: Dave Osage has over 50 years of experience in the refining and petrochemical industry as both an owner-user and consultant. He is responsible for engineering consulting services for pressure-containing systems including pressure vessels, piping, and tankage, and he provides engineering consulting for all levels of refinery capital projects. Mr. Osage is internationally recognized as an industry expert and leader in the development of FFS technology, as well as pressure vessel construction and risk-based inspection technology and software. Mr. Osage currently serves as Chairman of the Board of the Welding Research Council (WRC) and is also an Inspectioneering Journal Editorial Board Member.