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Why Coiled Tubing Fails and How to Avoid Failures in Your Well

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Coiled tubing (CT) is a simple concept: continuous metal tubing, wound onto a spool like a garden hose. Its uniform outer diameter affords deployment, storage and operational benefits that allow it to outperform jointed tubulars in many applications. However, CT is not as simple as it looks.

The cyclic bending strains imposed on CT during routine use are far beyond range typically imposed on engineering alloys. Therefore, fatigue is inevitable with CT. Understanding fatigue and plasticity behavior are critical to the successful implementation of CT in the field. The bending strains in CT can cause its diameter to grow (balloon) by more than 30%. The tubing also can elongate on the order of 10-12 feet each trip in and out of a 10,000 ft well. These events occur despite the fact that neither the circumferential pressure stresses nor the applied axial forces ever come close to yield stress magnitudes. The development and growth of fatigue cracks in CT also defy engineering logic. They appear where you might least expect, and sometimes (fortunately) not on schedule.

Not surprisingly, the fatigue endurance of CT can be affected by the presence of defects, which occur regularly in harsh oilfield environments. Shallow defects that penetrate the wall thickness by only a small percentage can reduce fatigue lives by an order of magnitude. On the other hand, large defects, driven through 1/3 of the wall thickness, have been shown to cause no reduction in fatigue life. Ongoing research is helping to quantify the influence of defects, and to develop techniques for making quick and cost-effective repairs in the field.

Defects must be detected to be analyzed. The development of reliable inspection technology provides another key to CT reliability. Magnetic flux leakage is the most common technique for finding flaws in CT. However, research is underway to adapt 3D laser imaging NDE, such that defect dimensions and geometry are fully characterized. Output from such techniques is directly compatible with software that can quantify defect severity in real time.



Steven M. Tipton is the Frank W. Murphy Distinguished Professor of Mechanical Engineering at the University of Tulsa, where he has taught for 25 years. He holds Ph.D. and M.S. degrees from Stanford University and a BS degree from Oklahoma State University, all in mechanical engineering. He conducts research in multiaxial fatigue and plasticity analysis, and is an

expert on coiled tubing mechanics. He is the director of the TU Coiled Tubing Mechanics Research Consortium. He is an active consultant to a wide range of industries, including petroleum, ground vehicle, aerospace, and sporting goods companies. He has 8 patents and others pending. He developed algorithms that predict the mechanical behavior and fatigue life of coiled tubing. Dr. Tipton's algorithms are currently used by the majority of the industry to monitor coiled tubing fatigue all over the world