

## Coke Drum Engineering Services

Damage assessment of coke drums is a highly-specialized engineering discipline whose objective is to determine the mechanical integrity, remaining economic life, inspection requirements, and need for long-term repairs of these failure-prone vessels.

### Patented Improvements

HES has five US and international patents on a non-welded skirt attachment, a non-bolted drum anchoring system, a bulge-resistant shell fabrication method, and a bottom unheading device with integral feed inlet, two of which have already been implemented. The company works with process licensors, coke drum designers, and fabricators to improve design details and maximize the lives of new and operating coke drums.

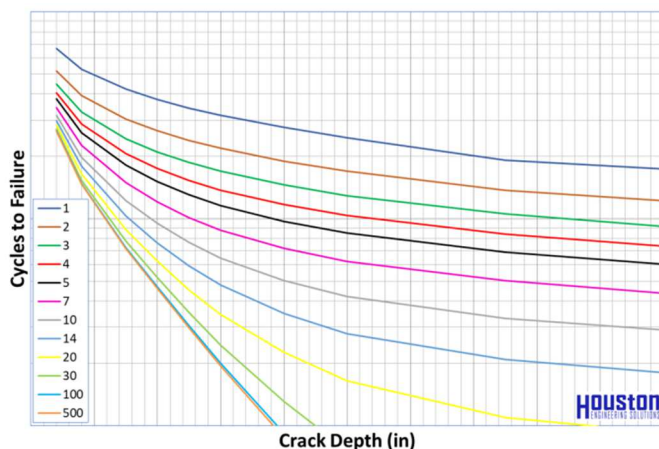
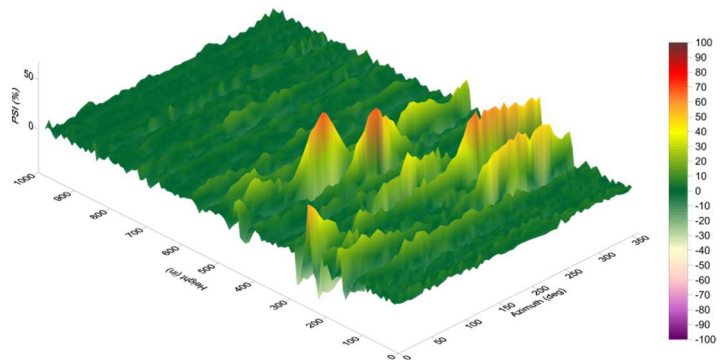


### Skirt Cracking

Cracking of conventional welded skirts occurs due to fatigue damage induced by cyclic thermo-mechanical stresses that develop during the course of the coking cycle. HES staff have a long history of analyzing coke drum skirts under severe mechanical and transient thermal loads and have developed out-of-the-box solutions including non-welded skirts and the first skirt retrofit of its kind in industry history in which a conventional skirt is converted to a non-welded skirt.

### Bulging Assessment

The Plastic Strain Index (PSI)<sup>TM</sup> is a proprietary methodology that was developed by HES for assessing the severity of bulging in coke drums. The strain-based technique identifies and ranks the areas that are most susceptible to failure on the inside and outside surfaces of drum wall using API 579/ ASME FFS failure limits that were calibrated using a database of internal and external bulging-induced cracks. PSI results are used as a basis for making decisions



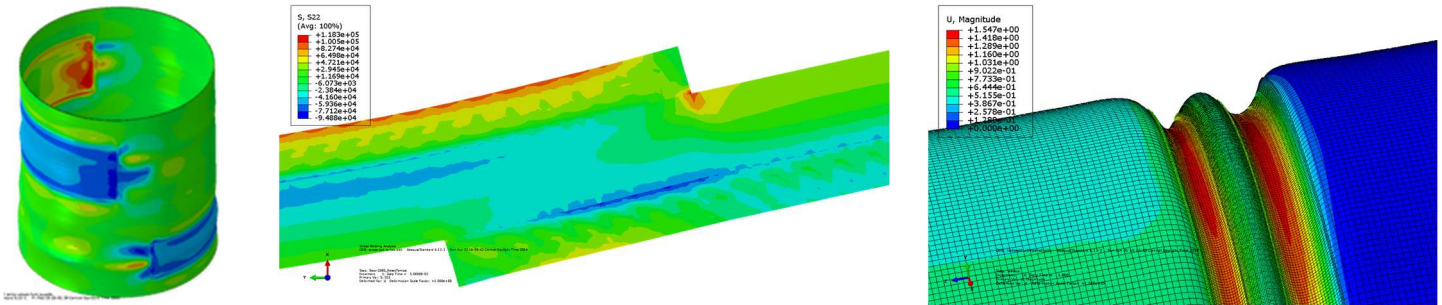
regarding future inspections, repairs, and replacement. As of 2021, more than 350 assessments have been performed using this state-of-the-art technique for refineries and upgraders around the world.

### Shell Crack Screening

When operators find hundreds of shell cracks that cannot be repaired during a turnaround, they look for ways to prioritize these cracks. HES uses fracture mechanics and its decades of experience to develop customized screening charts for clients' coke drums.

## Bulge Repairs

When bulging severity reaches unacceptably high levels, long-term repairs become necessary. Several approaches have been utilized to implement bulge repairs such as window replacement, can replacement, and weld overlay. Each technique has its advantages and disadvantages. The best repair method for a particular drum depends on the extent of damage, expected remaining service life, age, maintenance history, and drum design. Poorly-designed repairs can move the problem elsewhere or make a bad situation worse. HES staff have developed numerous bulge repair plans for clients around the world including the largest in industry history.

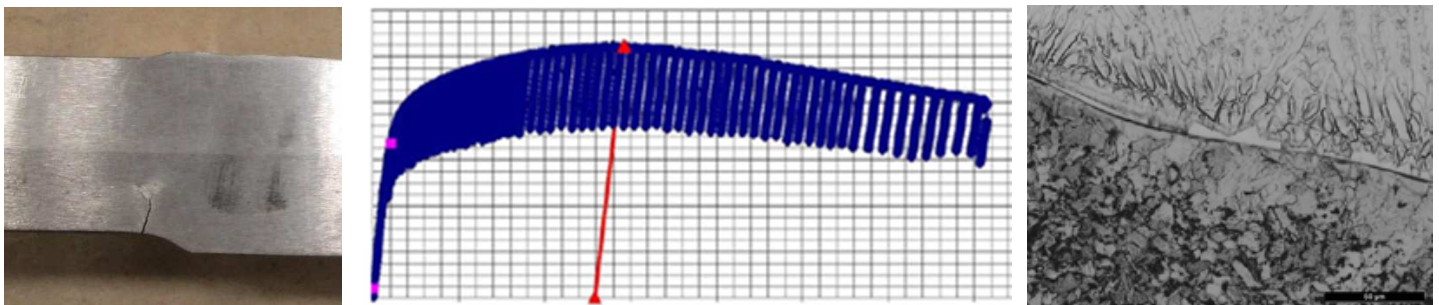


## Remaining Life Assessment and Extension

The definition of “end-of-life” varies according to applicable laws, risk tolerance, shutdown constraints, and availability and cost of repair facilities. Recent advances in the assessment and repair of coke drums has made it possible to extend their economic viability for decades after first crack. After identifying likely failure modes and reviewing inspection and maintenance records, HES helps clients develop customized inspection and engineering guidelines to extend the life of coke drums and effectively manage their integrity.

## Testing and Research

HES staff have managed large-scale leading-edge testing and research programs to better understand failure modes and post-failure behavior of coke drums and the effectiveness of various repairs methods. These programs included customized fatigue testing, complex load simulations, failure analyses, metallurgical examinations, experiment design, and model-test calibrations.



**HES is the only company in the world that was founded specifically to provide coke drum engineering services. The company’s unparalleled experience and state-of-the-art tools are relied upon by refineries and upgraders around the globe.**

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