

Cryotreatment

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Cryogenic Treatment Standards, Testing and Certification

In previous columns, we explored the science of cryogenic treatment (CT), examined the current state of the industry and surveyed types of CT chambers. Now we turn to the primary barrier preventing widespread adoption of cryogenic treatment: the absence of standards for manufacturing, processing, testing and certification.

On the hot side of thermal treatment, heat treaters have successfully commercialized their services through established quality systems that demonstrate:

1. Equipment is built to recognize safety and quality standards.
2. Processing follows defined industry procedures to achieve predictable results.
3. Testing verifies application of each thermal process and documents such proof.
4. Certification confirms compliance with documented data-based standards.

Equipment

"Classification rules and standards ensure the safety, reliability and quality of processes and products. Rules and standards also provide a foundation for creating products that conform to certain specifications and are compatible with products provided by different suppliers seeking the same quality, performance and interchangeability" (Class guideline, DNVGL-CG-0197, edition November 2017).

Commonly, thermal treatment equipment used by heat treaters meets UL and CSA electrical requirements, ASTM B51 boiler and pressure vessel specifications



Collage of UL, CE, CSA and ETCSA images. Credit: Jack Cahn/ETCSA



Cyclones. Credit: Jack Cahn/DCI

and AMS 2750 pyrometry standards. Engineering design and new furnace approval is crafted using a validation master plan and third-party qualifications. Country-of-origin stamps (Made in USA, Product of Canada, CE stamp) authenticate content. OSHA standards help reduce risk, ensure safe operation, provide legal compliance and mitigate hazards.

On the cold side, CT chambers can be manufactured to easily meet these same standards. The limitation is not technical, it is economic. Until demand grows, chamber

production remains confined to small-scale handcrafted builders. As adoption rises and consumers require engineering and quality approvals, existing furnace manufacturers (box, pit, I/Q) will likely take over, bringing the same platform of engineered safety, compliance and quality practices to CT chamber design.

Processing

Unlike heat treatment, which has evolved over 8,000 years, cryogenic treatment is relatively new (under 70 years). As a

result, no universally accepted CT processing standard exists. Key challenges include:

- Process dependency: CT effectiveness varies with alloy composition, prior heat treatment and failure mode
- Custom applications: Because no single CT recipe applies to all alloys, heat treaters often rely on specialized tribal knowledge developed within their facility

Most CT recipes are fairly similar (ramp down, low temp dwell, ramp up, temper) but the trigger mechanism and temperature to achieve toughness, added wear life, corrosion resistance or increased conductivity vary significantly among carbon and tool steel alloys, iron castings, carbide, aluminum and titanium. Although artificial intelligence, computer modeling and PID controllers will accelerate testing to correlate a CT process against predicted results, it will take extensive R&D while developing an AMS or ASTM CT standard to create go-to processing recipes that form a CT chapter within the ASM Heat Treater's Guide (military spec Mil-H-6875).

Testing

Few heat treaters possess in-house tools to verify CT applications or quantify improvements. Most heat treaters do not use quantitative methods (such as statistical testing, proxy coupon or model-based verification) to validate CT applications. Currently, customers rely on the service provider's word and a receipt or certificate as anecdotal proof of treatment. Since automotive, aerospace, power, oil and gas and mining all require test validation (such as NADCAP, ISO, API and MILSTD) and certification for part acceptance, the introduction of testing and validation coupled to end-item certification is essential for CT adoption.

Unlike heat treatment, which relies on the commonly accepted ASTM E18 Rockwell hardness test to measure increased hardness, E18 neither correlates positively nor negatively when parts have been cryogenically treated. Ideally, heat treaters need a reliable and accurate nondestructive test that measures changes resulting from CT in all classes of metallic materials that is ready for field



Proto Mxrd. Credit: Proto Mfg.

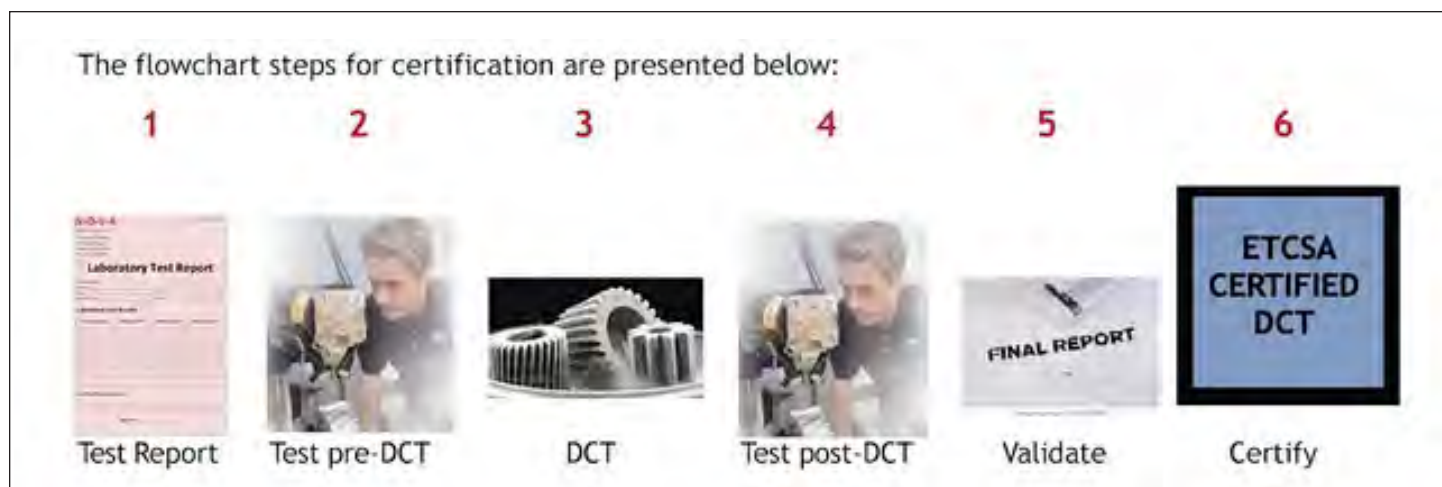


XRD of gear tooth. Credit: Proto Mfg.

use, available at reasonable cost and simple to operate. Could this test detect mechanical property improvements resulting from related surface treatments like shot peening, welding, hardfacing or cladding? Could it also measure nonvisual defects and be reliable as a failure analysis forensics tool?

This grand slam capability actually exists in X-ray diffraction (XRD) technology. Manufacturers like Proto, Stresstech and Rigaku produce portable XRD units that precisely measure residual stress, making them ideal for validating CT results.

XRD is a highly accurate means of characterizing residual stress in both surface and subsurface locations, making it a match to CT's through-core process in reducing vacancies, aligning interatomic spacing, precipitating micro-carbides and reducing both fatigue crack initiation and propagation. XRD can detect flaws and inclusions in cast and forged items, shifts in crystallographic planes, measure reduction in retained austenite and recognize phase change. It can also detect improvements in compressive stress caused by complementary processes like shot peening.



Flowchart. Credit: Jack Cahn/DCI

XRD testing can therefore validate CT effectiveness, confirm process application, reduce risk by detecting flaws and chart improvements to enhance part longevity.

Certification

The last step is certification: providing proof to a third-party customer, not present during cold thermal treatment, that an item has met the standards of test and validation. Luckily for heat treaters, there is no reason to reinvent the wheel.

In 1971, the Society of American Engineers published and approved a manufacturing, quality, test and safety standard for the automotive industry. Called SAE J784A, it details and advances residual stress measurement by XRD. In 2012, ASTM published E2860-12 Standard Test Method for Residual Stress Using XRD. Both standards are used extensively in aerospace, energy, medical and industrial products to ensure manufacturing quality, measure thermal treatment improvement and reduce risk.

By integrating recognized test and certification methods, the heat treat community can finally bridge the gap, bringing CT under the same framework that established conventional heat treatment as a trusted industrial process.

In our next column we will explore new and emerging opportunities for cryogenic treatment, particularly in markets yet to be tapped by the heat-treating industry . 🔄