

Comparison of NDT Methods for Heat Exchanger Tube Inspection

ECT · PSEC · FSEC · RFT · NFT · MFT · IRIS



	ECT Conventional Eddy Current	PSEC Partial Saturation EC	FSEC Full Saturation EC	RFT Remote Field Testing	NFT Near Field Testing	MFT Magnetic Flux Leakage	IRIS Internal Rotary Inspection System
	Applicable for: All non-magnetic materials (SS, Cu-Ni, Ti, Inconel, brass)	Applicable for: Slightly / partially magnetic (Duplex, super-duplex, CW SS, thin CS)	Applicable for: Strongly ferromagnetic (CS, LAS, T11, T22, P91, ferritic SS)	Applicable for: Ferromagnetic CS / LAS (heavy wall > 4 mm)	Applicable for: Ferromagnetic finned ACHE tubes (OD wall loss + fin-root corrosion)	Applicable for: Ferromagnetic CS only (requires external magnet contact)	Applicable for: All materials (incl. non-metals) Verification tool — not for screening
Advantages / Limitations	Advantages <ul style="list-style-type: none"> + Suitable for all paramagnetic / non-magnetic metals + Very good defect depth & size estimation (phase) + Internal + external defects (ID/OD) + Suitable for WT up to ~5 mm + High speed — up to 100 tubes / h + Tube-sheet area with rotating probes + Defects under baffle plates detectable + Cracks (circumferential + longitudinal) + No coupling medium (water) needed + Cleaning less stringent than IRIS + Defect type need not be known in advance 	Advantages <ul style="list-style-type: none"> + Bridges the μ gap between ECT and FSEC + Internal + external corrosion + Cracks (circ. + long.) — phase preserved + ID/OD discrimination via phase + Defects under baffle plates + High speed — up to 70 tubes / h + U-bend capable (compact magnet) + Tube-sheet area with rotating probes + No coupling medium needed + Same instrument as ECT and FSEC + Covered by ASTM E2884 	Advantages <ul style="list-style-type: none"> + DC bias → permeability noise eliminated + Internal + external corrosion + Stable, predictable skin depth + ID/OD discrimination via phase + Defects under baffle plates + General wall loss reliably detected + High speed — up to 70 tubes / h + Tube-sheet area with rotating probes + No coupling medium needed + Same instrument as ECT and PSEC + Covered by ASTM E2884 	Advantages <ul style="list-style-type: none"> + Effective for heavy-wall ferromagnetic tubes + Inspection speed considerably > IRIS + No coupling medium needed + Tolerant to scaling / less cleaning effort + Cracks (circumferential) detectable + Equal ID/OD wall-loss sensitivity 	Advantages <ul style="list-style-type: none"> + Optimised for ACHE finned tubes + Detects fin-root corrosion (bobbin EC may miss) + Internal probe — no external access required + Faster than RFT (~ 0.3 – 0.6 m/s) + No coupling medium needed + Tolerant to fin geometry 	Advantages <ul style="list-style-type: none"> + General + localised corrosion in CS tubes + Cracks (circumferential) detectable + Fin-fan tubes with external geometry access + No coupling medium needed + Tolerant to internal scale / deposits 	Advantages <ul style="list-style-type: none"> + Absolute wall thickness in mm (high accuracy) + Excellent defect geometry quantification + Excellent defect size quantification + Internal + external defects equally well + Defects under baffle plates + Suitable for general wall loss + All material types (material-independent TOF) + Provides datum for API 579 FFS
	Disadvantages / Limitations <ul style="list-style-type: none"> - Not applicable for ferromagnetic tubes (CS, LAS) - Magnetic deposits → false signals - No absolute wall thickness - Skilled personnel required (calibration) - Reference standard must match production tube 	Disadvantages / Limitations <ul style="list-style-type: none"> - Mixed defect types hard to interpret - Depth via amplitude in saturated zones - No absolute WT measurement - Highly skilled personnel required - Accuracy ± 10 % to ± 20 % - Sensitive to material variations 	Disadvantages / Limitations <ul style="list-style-type: none"> - Heavy magnet → straight sections only - Crack signature flattened by saturation - Mixed defect types hard to interpret - No absolute WT measurement - Highly skilled personnel required - Accuracy ± 10 % to ± 20 % - Larger probe diameter than ECT/PSEC 	Disadvantages / Limitations <ul style="list-style-type: none"> - Mainly limited to general wall loss - 10 – 20× slower than EC family - Compressed phase-vs-amplitude dynamic range - Highly skilled personnel required 	Disadvantages / Limitations <ul style="list-style-type: none"> - Niche method — finned ACHE tubes only - Qualitative output (amplitude-based) - Limited crack sensitivity - WT range limited to 1 – 3 mm - Manufacturer-specific calibration - Cannot replace bobbin EC for ID-side defects 	Disadvantages / Limitations <ul style="list-style-type: none"> - Not for general gradual erosion - Sizing of pits / defects not reliable - Defects under baffle plates difficult - Irregular pulling speed → misinterpretation - Bad data on rough surfaces / scaling - High set-up effort, error-prone - Highly skilled personnel required - No near-/far-surface discrimination - Longitudinal cracks not detected - Slower than FSEC - Excluded from ACHE, U-bends, insulated tubes 	Disadvantages / Limitations <ul style="list-style-type: none"> - Misses small pin holes (e.g. 1 mm dia. in SS) - Very low speed (max. 6 – 12 tubes / h) - High cost per tube due to low throughput - Bare-metal cleaning essential - Water coupling mandatory - "Dirt reflection" causes false signals - Pulling speed critical for 100 % coverage - Pulling speed normally not closed-loop - Water turbidity < 5 NTU required - Skilled personnel for false-signal rejection - Hard to apply in confined-space entry - Tube must be filled with water - U-bends cannot be inspected - Sensor centring critical