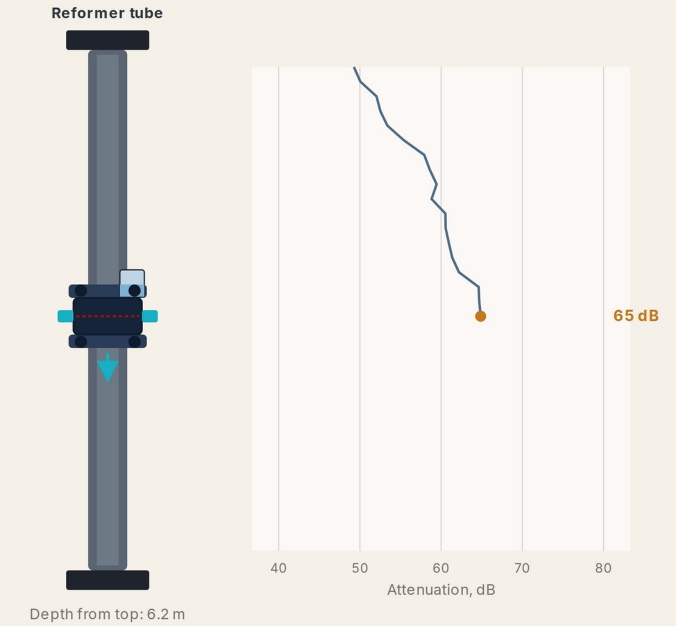
ASSET INTEGRITY · REFORMER TUBES

ARTiS

Automated Reformer Tube Inspection System

Condition assessment, Fitness-for-Service and Remaining Life Assessment to API 579-1 / ASME FFS-1, Level 3. One robotic crawler, four measurements, a retirement date for every tube.

Transparency. Competence. Reliability.



JIMA 2026 · Japan Inspection Instruments Manufacturers' Show
16 to 18 September 2026 · 10:00 to 17:00
Tokyo Big Sight, East Halls 1 to 3, Tokyo

ASSET INTEGRITY · REFORMER TUBES

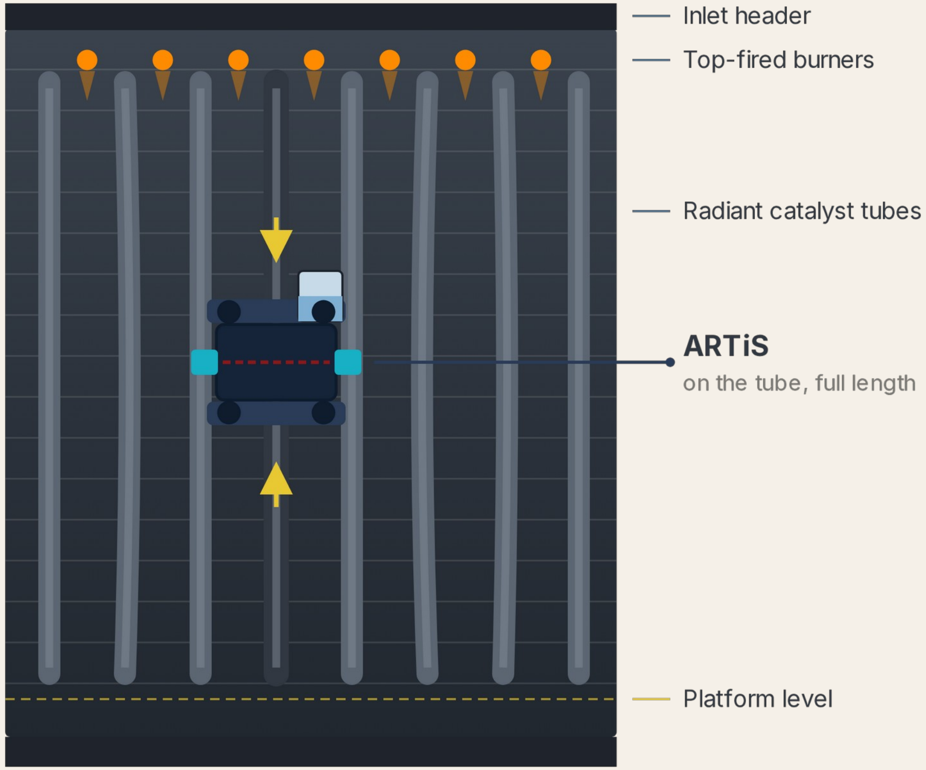
THE QUESTION THAT GOVERNS THE SHUTDOWN

An inspection that tells you a tube is damaged has answered the easy question. ARTiS answers the one that governs the shutdown: when does this tube come out?

Condition assessment, Fitness-for-Service and Remaining Life Assessment to API 579-1 / ASME FFS-1, Level 3. One robotic crawler, four measurements, a retirement date for every tube.

WHERE THE TUBES SIT, AND WHY ACCESS IS THE PROBLEM

- Primary reformer tubes crack hydrocarbons over a nickel catalyst above 800 °C under internal pressure. Creep is not a failure mode that waits: an overshoot of 10 to 20 °C in tube metal temperature roughly halves tube life.
- Damage appears first as diametral growth of 1 to 6 percent, then as creep voids at mid-wall, then aligned voids, mid-wall fissures and bowing. By the time a tube is visibly distressed the decision window has already closed.
- The owner's question is never whether a tube is damaged. It is which tubes come out at this shutdown, which survive to the next, and what the reformer is worth running at until then.



Radiant box, up to 15 m tube height

REFORMER TUBE LIFE IS NOT FORGIVING

100,000 h

Design life of a reformer tube, about 11.5 years

200,000 h

Achieved on the same tubes with operational control and periodic inspection, about 23 years

10-20 °C

Tube metal temperature overshoot that roughly halves tube life

0.8

Life fraction at which ARTiS sets the retirement date

Rising throughput shortens reaction time and pushes furnace temperature up. Reformer tube inspection is now one of the most focused activities in a turnaround.

TUBE LIFE IS SET BY OPERATION, NOT METALLURGY

Reformer tubes are designed for 100,000 hours, about 11.5 years. Plants that operate within the envelope and inspect on a cycle have run the same tubes past 200,000 hours, about 23 years. The gap between those two numbers is operational control, and it is worth more than any alloy upgrade.

Every tube runs at the edge of its creep limit

At roughly 900 °C and 25 to 30 barg there is minimal margin for error. Minor process variation, nominal or local, raises skin temperature and cuts creep life.

Measured tube metal temperature is not reliable

Optical pyrometers work on emissivity. A new rough tube reads near 0.9; oxidation smooths the surface and emissivity falls towards 0.6. The reformer is then being run on a temperature that is wrong.

Catalyst condition moves the temperature

A catalyst changeover alone gives an 8 to 10 °C reduction. Friable catalyst chokes the gas path, raises skin temperature and shows up as inlet-to-outlet pressure difference.

Start-up and shutdown are where damage accumulates

Over-firing risk peaks during start-up and transients. Excessive cooldown rate induces thermal shock and uneven contraction, which is what bows a tube.

ARTiS does not ask what temperature the pyrometer read. It back-calculates the effective tube metal temperature that produced the damage actually present, then projects forward from that.

SIX MECHANISMS ONE TECHNIQUE CANNOT SEPARATE

Creep damage

Continuous exposure above the creep threshold. Voids initiate mid-wall, align, and link into fissures. Reflected as diameter growth.

Metallurgical degradation

Carbide coarsening and secondary carbide dissolution between 700 and 1000 °C. Creep rupture strength falls even where no crack exists.

Localised overheating and thermal shock

Burner misalignment, flame impingement, catalyst channelling, trip and restart transients. Abrupt, and not predictable from creep data alone.

External oxidation, or baldness

The protective chromia layer on 25Cr-35Ni spalls under thermal cycling. Effective wall is lost while OD appears to fall, masking true creep strain.

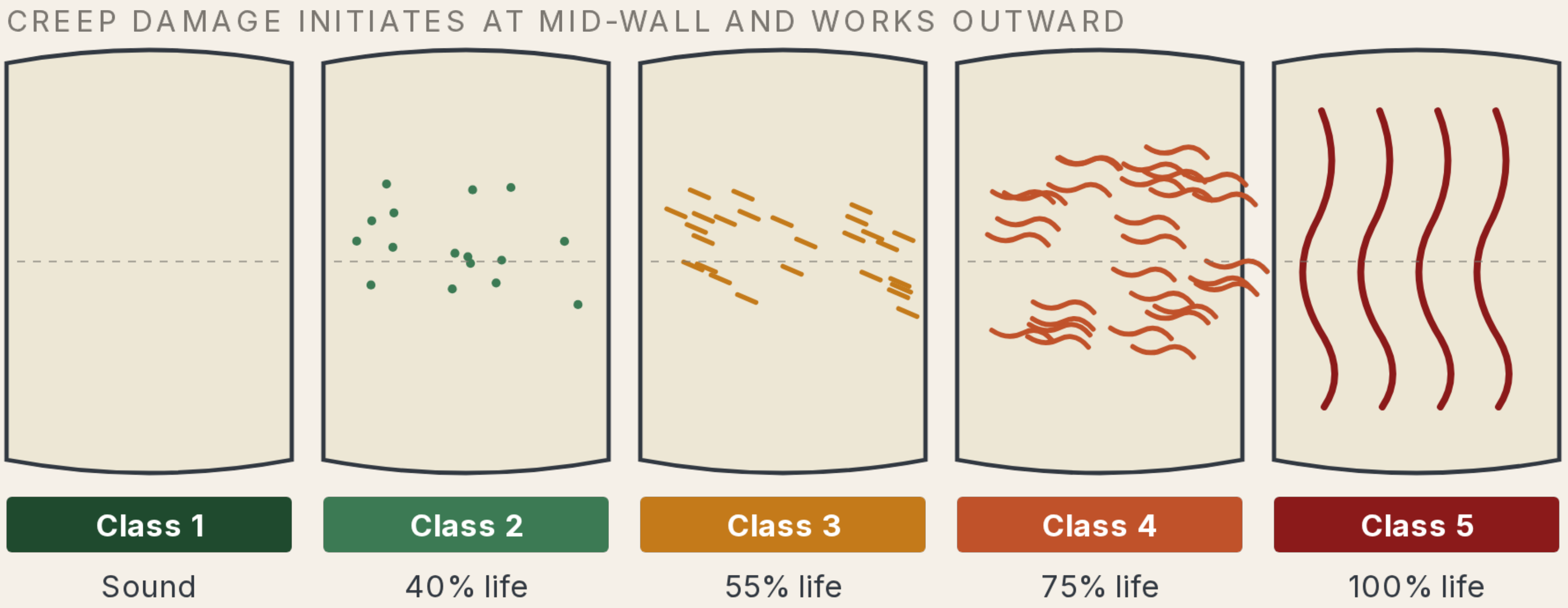
Bowing and wedging

Thermal cycling, uneven firing, damaged supports. OISD accepts bowing to 1.5 x OD provided adjacent tubes are not wedged.

Catalyst deterioration

Nickel pellets attrit and channel the gas path, producing hot bands, tiger tailing and giraffe necking, and local temperature rise.

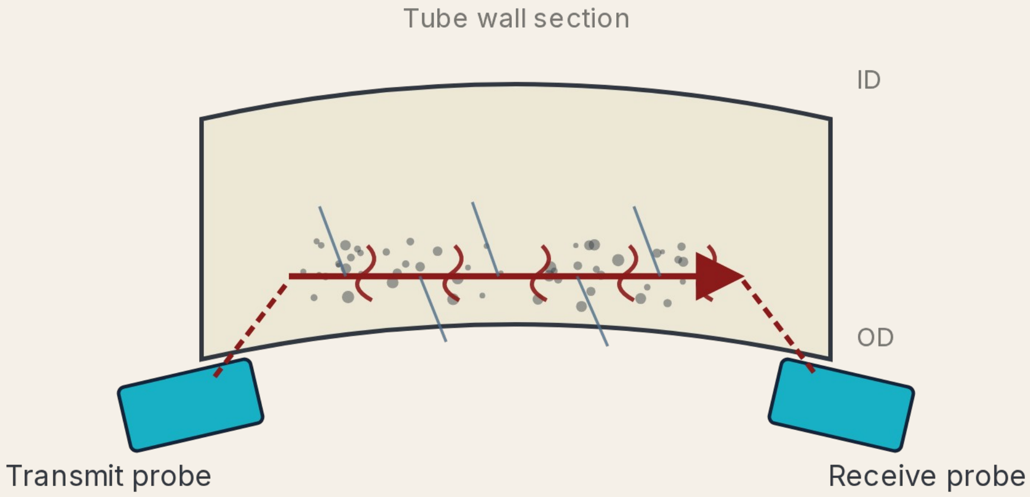
HOW CREEP DAMAGE ADVANCES THROUGH THE WALL



Damage initiates at mid-wall. By the time cracking reaches the outer wall, where a surface method could find it, roughly three quarters of tube life is already spent.

TRANSMIT-RECEIVE ULTRASONICS: READING THE MID-WALL

- Ultrasonic inspection runs in transmit-receive mode. Energy enters the wall at one probe, travels through mid-wall, and is received at the other. What arrives is what was sent minus what scattered.
- In as-cast metal the beam scatters at dendrite boundaries and primary carbides. With service exposure, secondary carbide precipitation adds to the scatter. With creep, voids add more; once voids align into mid-wall fissures, through-transmission is blocked and attenuation rises sharply.
- TCR reads the resulting decibel value against a reformer-tube reference base built from roughly 1,000 catalogued microstructure locations and a set of standard samples with known damage. That reference base is why a number becomes a judgement rather than a reading.

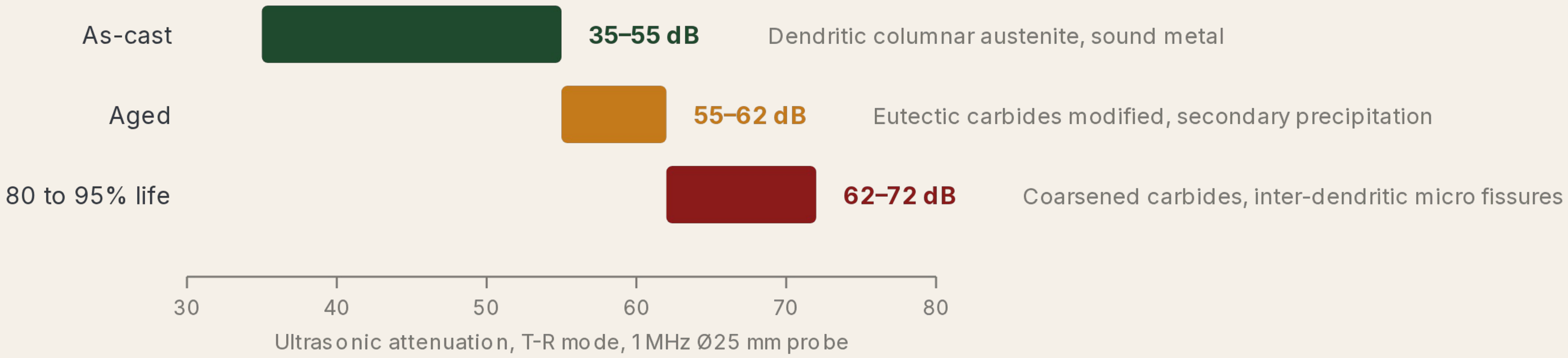


Beam scatter at carbides, creep voids and mid-wall fissures

Energy transmitted = energy received + energy lost in scatter

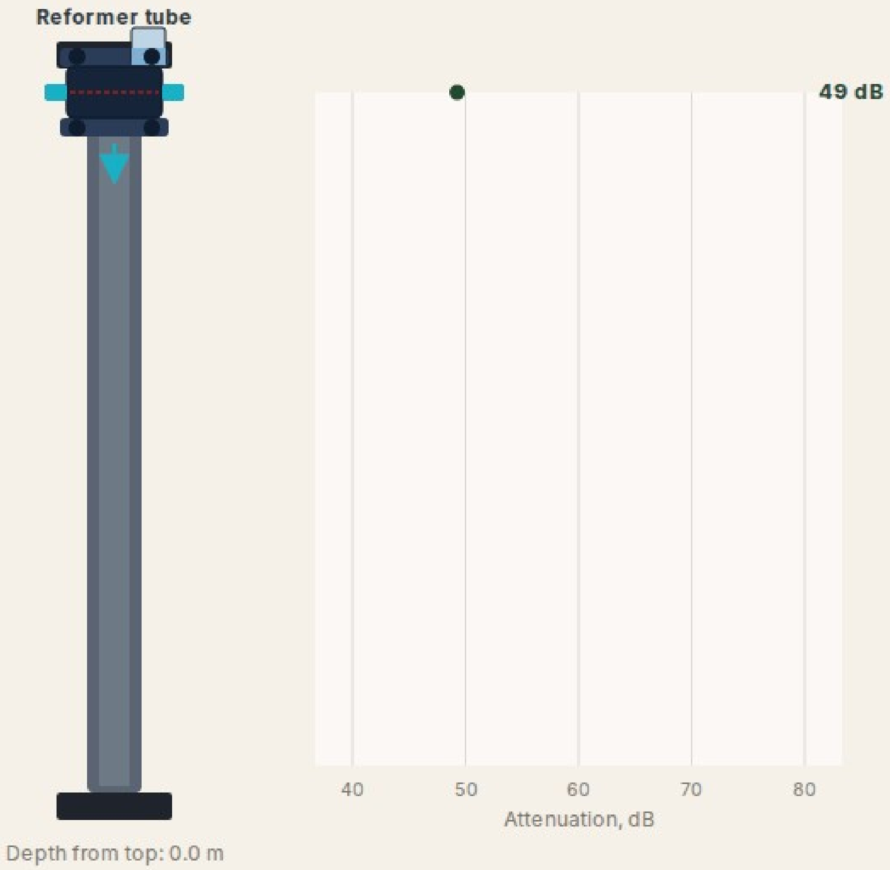
WHAT THE DECIBEL VALUE IS READ AGAINST

MICROSTRUCTURAL DEGRADATION READ AS ATTENUATION



The reference base is built from roughly 1,000 catalogued microstructure locations and a set of standard samples with known damage. It is what turns a decibel reading into a judgement.

THE CRAWLER ON THE TUBE



- Four metal gear motors, 200 W total, clamped by spring-locked arms
- Rubber padded shoes carry the transmit-receive probes, coupled with demineralised water
- Infrared sensors read outer diameter on the move; gyroscopic sensors record angle for bowing
- One reading every 100 mm over the full radiant length, descending and returning

Animated in slideshow mode. Attenuation trace is illustrative.

FOUR MEASUREMENTS, ONE PLATFORM, ONE PASS

ARTiS

Ultrasonic attenuation

Creep voids and mid-wall fissures, T-R mode

35 to 72 dB · 0.1 dB resolution

Outer diameter

Creep strain along the whole tube

every 100 mm · 0.5% of OD

Tube bowing

Gyro-measured, quantified not eyeballed

5 to 200 mm · digital output

Effective tube metal temperature

T-Eff back-calculated, then remaining life

API 579-1 / ASME FFS-1 Level 3

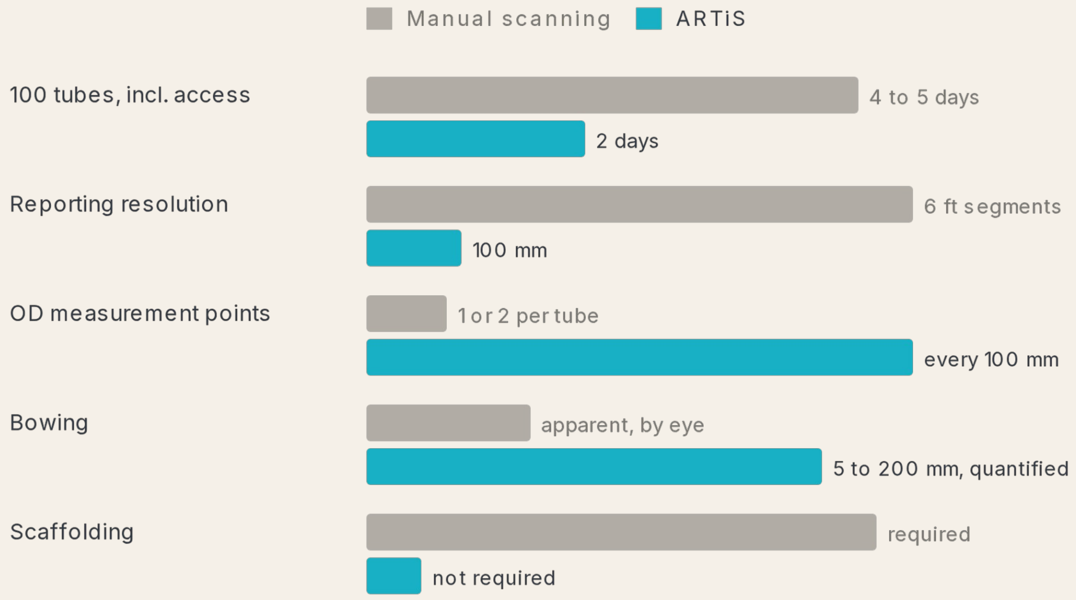
TECHNICAL SPECIFICATION

Tube OD range	105 to 190 mm
Scan speed	2 to 5 min / 10 m
Scan resolution	100 mm
Fixing time	3 min per tube
Climbing height	15,000 mm max
Diameter sensing	IR, 0.5% of OD

Bowing sensing	Gyro, 5 mm min
UT probe	Ø25 mm, 1 MHz, T-R
Range / resolution	30 to 100 dB / 0.1 dB
Drive	4 gear motors, 200 W
Couplant	500 ml DM water / 10 m
Operating range	10 to 40 °C, 20 to 80% RH

TCR ENGINEERING · TCR ADVANCED · Chugai Technos

AGAINST MANUAL SCANNING



Bar length is proportional within each row. Source: TCR ARTiS field records.

2 days

for 100 tubes

against 4 to 5 days manual, including access

100 mm

reporting resolution

against 6 ft segments manual

None

scaffolding required

the crawler climbs the tube it inspects

FROM RAW SCAN TO A DATE IN THE TURNAROUND PLAN

01
Scan
OD, thickness, dB, bowing

02
Creep strain
per tube, against nominal ID

03
T-Eff
Larson-Miller back-calculation

04
Accumulated damage
T-Eff against hoop stress

05
Retirement date
the 0.8 life fraction

API 579-1/ASME FFS-1 Level 1 passes below a damage fraction of 0.25. Where it does not, ARTiS carries the assessment to Level 3 rather than stopping at a pass or fail.

DAMAGE CLASSIFICATION, AND THE ACTION IT CALLS FOR

Class	Condition	Life consumed	Action
1	As-cast, sound material	—	Continue in service
2	Creep voids at the inner wall	40%	Continue; re-assess next inspection
3	Aligned voids and cracking, inner to mid-wall	55%	Increase monitoring
4	Creep cracking, mid-wall to outer wall	75%	Plan replacement
5	Macro-cracking through 75% or more of wall	100%	Replace immediately

WHAT TCR DOES ON SITE, AND WHAT YOU RECEIVE

WHAT HAPPENS ON SITE

- Visual inspection by an experienced metallurgist: general appearance, bulging, baldness, sagging and bowing
- Outer diameter along the full tube by on-board infrared sensors, at 100 mm intervals
- Bowing by on-board gyroscopic sensors, quantified rather than estimated
- Ultrasonic attenuation in dB for creep fissure detection, by automated crawler
- In-situ metallography by surface replication to establish microstructural degradation
- Hardness measurement at each metallography location
- Manual ultrasonic wall thickness of every tube at platform level
- Manual outer diameter of every tube at platform level
- Magnetic permeability of every tube at platform level, for internal carburisation

WHAT IS DELIVERED

01 Level 3 assessment to API 579-1 / ASME FFS-1, Part 10

02 Accumulated creep damage per tube as at the date of inspection

03 Effective tube metal temperature (T-Eff) calculated for each tube

04 Theoretical accumulated damage projected to the next shutdown, four years on

05 The date at which accumulated creep damage exceeds the 0.8 life fraction

06 Remaining life, tube by tube, with a sensitivity case at a second temperature

THE RECORD BEHIND THE READING

53
years
since 1973

100+
reformer assignments
80+ with ARTiS

50,000+
tubes scanned
cumulative

100,000+
replica microstructures
reference base

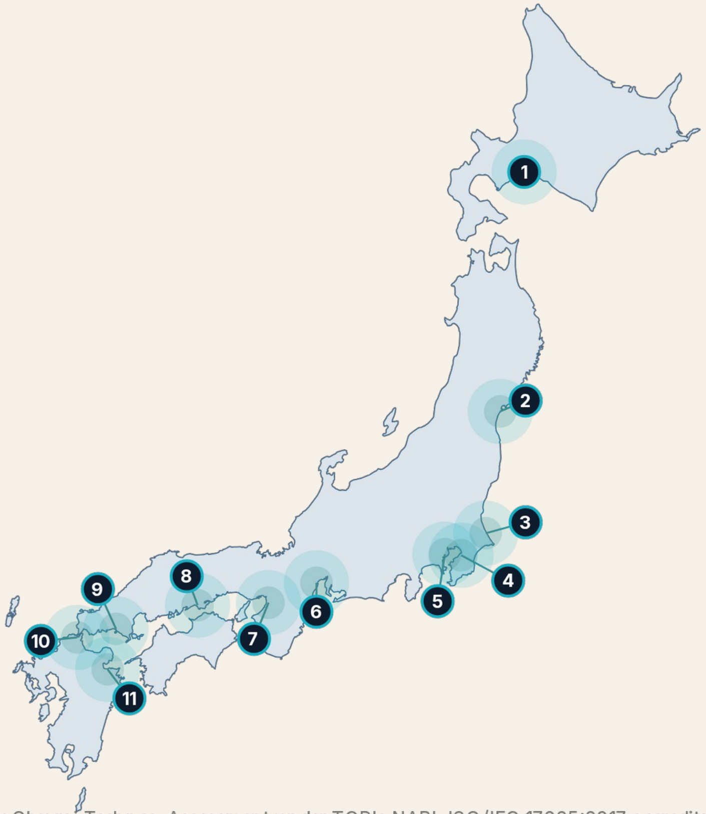
7
countries
India, GCC, Japan, SE Asia

TC-6739
NABL ISO/IEC 17025
ILAC MRA, 90+ economies

Owners of hydrogen, ammonia and methanol reformers. Tube materials include HP modified micro-alloyed grades, G4852 Micro, KHR35CT, HP39W, IN519, HK40 and proprietary alloys such as Manaurite XM.

WHERE THE PRIMARY REFORMERS ARE IN JAPAN

COASTAL HEAVY-INDUSTRY BELTS WHERE PRIMARY REFORMERS SIT



COASTAL BELTS

1. Tomakomai / Muroran
2. Sendai / Tohoku coast
3. Kashima
4. Keiyo (Chiba-Ichihara)
5. Keihin (Kawasaki-Yokohama)
6. Chukyo / Yokkaichi
7. Sakai-Senboku / Osaka Bay
8. Mizushima
9. Shunan / Iwakuni-Otake
10. Kita-Kyushu belt
11. Oita

Refining	Hydrogen plants on refinery reformers
Petrochemical	Steam and auto-thermal reformers
Ammonia and fertiliser	Primary reformers, catalyst tubes
Methanol and hydrogen	Merchant and captive hydrogen units
Industrial gases	On-site hydrogen generation

Mobilised to site by Chugai Technos. Assessment under TCR's NABL ISO/IEC 17025:2017 accreditation, accepted in 90+ economies under the ILAC MRA.

WHAT THE ALLIANCE CARRIES, IN BOTH DIRECTIONS

AiOM, Asset Integrity and Optimisation Management

TCR's asset integrity platform: damage-mechanism taxonomy, inspection planning and the corrosion-intelligence layer that carries findings from one turnaround to the next

Corrosion and sour service

HIC to NACE TM0284, SSC to NACE TM0177 Methods A to D, qualification to NACE MR0175 / ISO 15156

Creep and stress rupture

ASTM E139, including accelerated creep rupture for boiler and reformer tube remaining-life work

Failure investigation and RLA

Root cause analysis from a group base of 9,000+ investigations, with in-situ metallography and boiler audit

Fitness-for-Service, API 579-1 / ASME FFS-1

Level 1 to Level 3 assessment across pressure equipment, piping, heater and reformer tubes and tanks, with remaining life and a re-assessment interval

Fatigue and fracture toughness

CTOD to BS 8571 and ISO 15653, K1c to ASTM E399, J-integral to ASTM E1820, crack growth to ASTM E647

Robotic radiographic crawlers

Pipeline RT crawlers and robotic tank inspection, from a base of 2,600+ km of pipeline radiography

And what comes the other way

Chugai Technos capability moves into India and the Gulf through TCR: the Scale Checker, a radioisotope system that measures scale, sludge and fouling inside live pipelines without removing insulation or stopping flow, now part of TCR's power-sector inspection stack and being marketed in India; drone structural inspection with crack detection to 0.2 mm; and Japanese-grade environmental and emissions testing.

TCR AND CHUGAI TECHNOS IN JAPAN

TCR serves Japan through Chugai Technos Corporation of Hiroshima under a memorandum of understanding signed on 29 April 2026: two founder-led technical services firms, TCR established 1973 and Chugai Technos 1953. Field deployment in Japan is coordinated by Chugai Technos; assessment and laboratory work runs under TCR's NABL ISO/IEC 17025:2017 accreditation, accepted in more than 90 economies under the ILAC MRA.

JIMA 2026 · Japan Inspection Instruments Manufacturers' Show

16 to 18 September 2026 · 10:00 to 17:00
Tokyo Big Sight, East Halls 1 to 3, Tokyo

Chugai Technos Corporation
9-12 Yokogawashinmachi, Nishi-ku, Hiroshima City, Hiroshima 733-0013, Japan
Tel +81-82-295-2222

Naoshi Kawabe
n.kawabe@chugai-tec.co.jp
+81 70-4205-9826

Talk to us

Chugai Technos Corporation
Naoshi Kawabe · n.kawabe@chugai-tec.co.jp
+81 70-4205-9826

TCR Engineering Services Pvt. Ltd.
TCR Advanced Engineering Pvt. Ltd.
sales@tcreng.com · www.tcreng.com
NABL (TC-6739) ISO/IEC 17025:2017 · NADCAP AC7101

Transparency. Competence. Reliability.