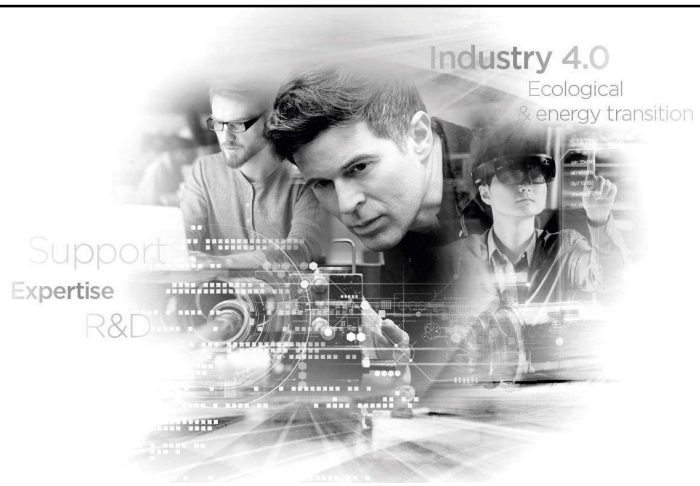


CETIM, your global technological engineering partner

Towards a sustainable and efficient industry

CETIM

1

1

Cetim-Matcor Company Presentation

2

Cetim Group

The Technological Centre of Mechanics, steered by Mechanical Engineering Industrials

- Since 1965, Cetim is a leading engineering group, supporting Mechanical Engineering Companies' Access to R&D and Innovation for their Competitiveness
- Main technology partner for Industry 4.0, digital roll out & sustainability
- French leader, worldwide player

3

3

R&T Institute and Engineering Company

1000+ Experts in France, Morocco, Tunisia, Singapore, Malaysia, Japan
150 experts participating in Standardization committees (ISO, CEN, ASME…)

20 - Main locations
France & Worldwide…

1,100 - Employees

180 M€ - Annual sales
including 90 M€ in R&D and Innovation projects & programs

20% - International Sales

14,000 + Active annual clients worldwide

4

4

Our fields of expertise

Unique R&D capabilities and Multi-disciplinary competencies

1000+ Experts in France, Morocco, Tunisia, Singapore, Malaysia, Japan
150 experts participating in Standardization committees (ISO, CEN, ASME…)

- Metallic Materials and Surfaces
- Polymers & Composites Engineering
- Advanced Manufacturing Processes
- Assembly Technologies
- Integrated Production Systems
- Foundry, Forge & Hot Metallurgy

- Fatigue Optimisation Durability
- Simulation
- Power Transmission
- Fluid and sealing technologies

- Industry 4.0
- Sustainable Industrial Performance
- NDT, NVH & IIoT
- Metrology & Calibration Expertise

Strategic and Technological Intelligence | R & D Innovation | Testing, Characterization & Validation | Failure Analysis Forensic Engineering Asset Integrity | Consulting Expert Analysis | Training and Skills Management

5

5

Cetim-Matcor Technology & Services Pte Ltd

Cetim Asia Pacific HQ, Singapore



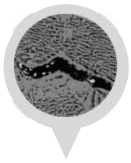

- Established in Singapore in 1992
- Merged with Cetim in 2018
- Leading Specialist in Failure Analysis, Forensic Engineering, Materials (Metallic / Composite), Corrosion, Power Transmissions, Asset Integrity Management, NDT, RBI, RLA, 3D Scanning and Data processing, Training…
- Supporting all industries, over 10,000 projects completed since inception

6

6

Our APAC Centre of Excellence

Extend the LIFE CYCLE of your industrials Products and Systems




Failure Analysis & Forensic Engineering

- Site Investigations
- Laboratory Examinations
- Material Characterization
- Expert Witness (litigation and insurance)
- Digitalization & Simulation
- Fire Investigation

Asset Integrity Management

- Inspection
- Advanced NDT
- Digitalization & Simulation
- RLA / FFS / RBI / TA
- IIoT - SHM & Predictive maintenance
- Digital Twins

Sustainable Industry

- Industry 4.0
- Operational Safety
- Hydrogen
- Life Cycle Analysis
- Carbon footprint

MATERIALS:
Metals (Conventional and Additive Manufacturing) & Composites, Polymers, Glass…

Research & Development | TRAINING | SOFTWARE

In APAC, we support over 2,000 clients in all industries


AUTHORITIES & INSURANCES


OIL & GAS


ENERGY


MARITIME


METALLIC STRUCTURES


RAILWAY


AEROSPACE & DEFENSE

7

7

Failure Analysis & Forensic Engineering

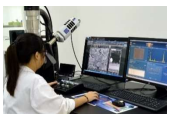
Our clients are facing

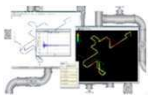
- a malfunction
- a non-performance (insufficient efficiency…)
- an abnormal wear
- an operating anomaly (noise, vibration….)
- a risk of rupture (crack, corrosion…)
- a suspected defect (NDT indication, …)
- a doubt (detected by the quality department)
- a mixture of parts
- a consequence of an accident, fire, deformation

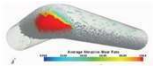
We provide

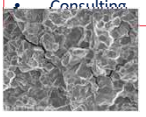
- Site Investigations
- Laboratory Examinations
- Material Characterization
- Fire Investigation
- Consulting
- Recommendations
- Expert Witness (litigation and insurance)


On-site inspection


Lab Testing

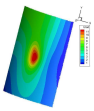

CFD – 2D

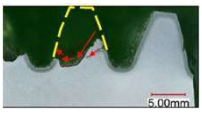

CFD – 3D


Digital Fractography


Rotating Machine Failure





Digitalization



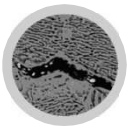
From failure to design

8

8

Failure Analysis & Forensic Investigation Lab

Some of our Metallography, Analysis and Testing Equipment



Documentation — **Sample Preparation** — **Testing** — **Investigation** — **Detailed Analysis**

For deep and accurate assessment

9

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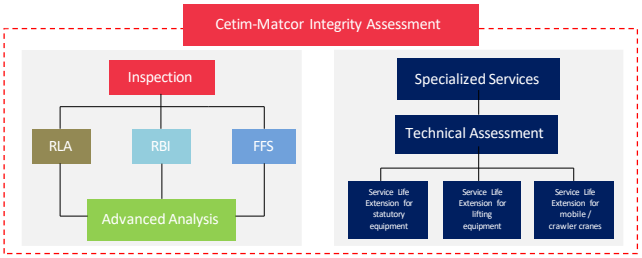
Asset Integrity



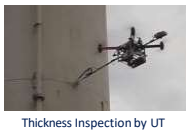
- Inspection Planning > Inspection > RBI & RLA
- Suitability for continued operation > Inspection, FFS, RLA, Advanced Analysis
- Life Assessment > Inspection, RLA, Advanced Analysis
- **Matcor has the capability to provide comprehensive services on Integrity Assessment**

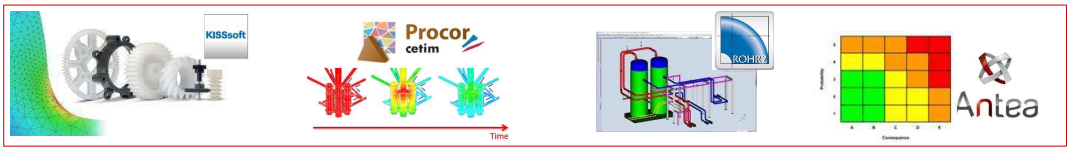

Pressure Vessels


Metallic Structures


Rotating Equipments


Phased array UT


Thickness Inspection by UT



10

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Sustainable Industry

Identified Frameworks in Cetim Matcor

SUSTAINABLE INDUSTRY

Energy Transition	Ammonia fuel Hydrogen Fuel Materials for Hydrogen
Energy & Materials Efficiency	Eco-Design & Life Cycle Analysis Material and process sustainability, Green solutions, Recycling Residual life assessment
Decarbonisation	Carbon Footprint Carbon Capture, Utilisation & Storage (CCUS)

Excellence and innovation of fundamentals in mechanics

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R&D at CETIM-MATCOR

Main Themes

Innovation in Mechanics & Materials

Corrosion:
- Drone assisted NDT

Metallic Materials
- Ultrasonic inspection of AM
- Design for onsite inspection
- Resistance to H2 in AM
- Creep modeling
- Fatigue modeling in AM

Composites and Polymers
- Failure of pressure vessels
- Thermal test after corrosion
- Resistance to H2/cryogenic

Digital Transformation & Operational Excellence

PROCOR
Smart Inspection
- Galvanic Corrosion
- Green inhibitors modeling
- AR in inspection

ML and AI
- DesCartes and Hybrid AI
- FraD
- Corrosion detection
- Scene recognition

Structural Health Monitoring
- Digital twin implementation
- AIM
- RLA, FEA ...

Energy Transition & Sustainable industry

Energy Transition
- Ammonia as alternative fuel
- Hydrogen Adsorption
- Hydrogen Diffusion
- Materials for Hydrogen

Decarbonisation
- Carbon capture, utilization & storage
- Recycling
- Green solutions

Energy Efficiency
- Life Cycle Analysis
- Residual Life Assessment
- Carbon Footprint
- Sustainability in AM

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Research & Development

Collaborative Projects examples

Additive Manufacturing for Energy Transition

Joint Lab – Process and Part Qualification in WAAM

Asset Integrity Management for Sustainable Industry

Effective Structural Health Monitoring, Predictive Maintenance through smart sensors and Hybrid AI

Artificial Intelligence in Failure Analysis

Applied research in deep learning for fractography and optimized workflow

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Our Training Centre

Learn to Extend the LIFE CYCLE of your industrial Products and Systems

Methodology

- Failure Analysis & Forensic Engineering
- Damage Mechanisms
- Risk-Based Inspection
- Life Cycle Analysis
- Residual Life Assessment

Material Expertise

- Corrosion Fundamentals
- Metallic Materials
- Composites
- Metal Additive Manufacturing

Product Performance

- Shafts, Gears and Bearings
- Cranes
- Pipes
- Calculations / Simulation

Also available In Partnership with: NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE; SIRIM STS; UPM EDUCATION & TRAINING WHOLLY OWNED BY UPM HOLDINGS SDN BHD

Standard & customised training are available

https://cetim-matcor.com/training-courses

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Certifications and Licenses

ISO 17020

ISO 17025

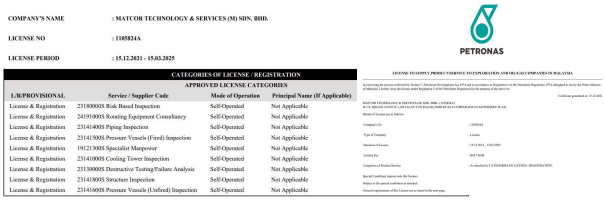
HSE

CERTIFICATE NUMBER : ASA-00455

PRATT & WHITNEY & THE SINGAPORE AIR FORCE
End Users Licenses D1062099 & D1061996 for Military Gas Turbine Engine

Pratt & Whitney

RSAF



COMPANY'S NAME : MATCOR TECHNOLOGY & SERVICES (M) SDN. BHD.

LICENSE NO : 1105824A

LICENSE PERIOD : 15.12.2021 - 15.03.2025

CATEGORIES OF LICENSE / REGISTRATION

APPROVED LICENSE CATEGORIES

L/R/PROVISIONAL	Service / Supplier Code	Mode of Operation	Principal Name (If Applicable)
License & Registration	231800003S Risk Based Inspection	Self-Operated	Not Applicable
License & Registration	241910003S Rotating Equipment Consultancy	Self-Operated	Not Applicable
License & Registration	231414003S Piping Inspection	Self-Operated	Not Applicable
License & Registration	231415003S Pressure Vessels (Fired) Inspection	Self-Operated	Not Applicable
License & Registration	191213003S Specialist Manpower	Self-Operated	Not Applicable
License & Registration	231410003S Cooling Tower Inspection	Self-Operated	Not Applicable
License & Registration	231500003S Destructive Testing/Failure Analysis	Self-Operated	Not Applicable
License & Registration	231418003S Structure Inspection	Self-Operated	Not Applicable
License & Registration	231416003S Pressure Vessels (Unfired) Inspection	Self-Operated	Not Applicable

PETRONAS

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Our clients and partners

Energy Sector:

Senoko energy for life · EDF · bp · ENGIE · NESTE · TUAS POWER SUPPLY · FLOWSERVE · GE · YTL POWER SERAYA · TechnipFMC · subsea 7

Engineering Sector:

Infineum · KSB · ST Engineering · SURBANA JURONG · Schlumberger · CAMERON A Schlumberger Company · SULZER

Education Sector:

NANYANG TECHNOLOGICAL UNIVERSITY · NUS National University of Singapore · SINGAPORE POLYTECHNIC SP · SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Oil & Gas Sector:

Shell · ExxonMobil · PETRONAS · Chevron · Air Liquide · THE LINDE GROUP · TOTAL

Health Sector:

MSD · Biolidics · gsk · 3D MEDLAB

Transport Sector:

SAFRAN · THALES · arianeGROUP · Rolls-Royce · AIRBUS

Authorities:

MINISTRY OF MANPOWER · SINGAPORE POLICE FORCE · SCDF The Life Saving Force · DSTA Defence Science & Technology Agency

Running projects in partnership with:

NANYANG TECHNOLOGICAL UNIVERSITY · NUS National University of Singapore · SpareParts3D · Accuron Technologies · DNV·GL · vallourec · cnrs

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CETIM MATCOR

Contact:

Pauline Le BORGNE

+65 6661 0727
+65 9325 4552
pauline.LB@cetim-matcor.com

Extend the life cycle of your industrial products and systems

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CETIM

Acoustic Emission Testing

A global NDT technology for Asset Integrity and In-service Inspection

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Acoustic Emission Testing Summary

- A global NDT technology for Asset Integrity and In-service Inspection
  - Scope and objectives
  - How this works
  - Codes and Standards
- ❑ Steps Involved in AET
- ❑ Markets and Applications for AET
- ❑ Acoustic Emission : A monitoring technique

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CETIM

Acoustic Emission
A long & rich history at CETIM

International recognition from the 1970s

Very strong growth in our activity from 2000
(mainly Pressure Equipment controls)

Today, CETIM has one of the biggest park in the world in terms of data acquisition systems
(> 400 channels)
&
Strong Industry experience + many monitoring experiences for more than 3 decades

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Acoustic emission testing – Scope and Objectives

Scope

Acoustic Emission Testing (AET) is a **global NDT** technique that detects and monitors the release of ultrasonic stress waves from localized sources when asset is under stress.

Objectives of AET

- Monitor the equipment behavior during hydraulic/pneumatic pressure load (case of PV) or other type of load (tank, bridge, …)
- Early Detect critical defects which might lead to premature deterioration of the asset.
- Give a diagnosis on the health status of the asset in order to undertake if necessary complementary non-destructive testing on the emissive areas localized by AE.

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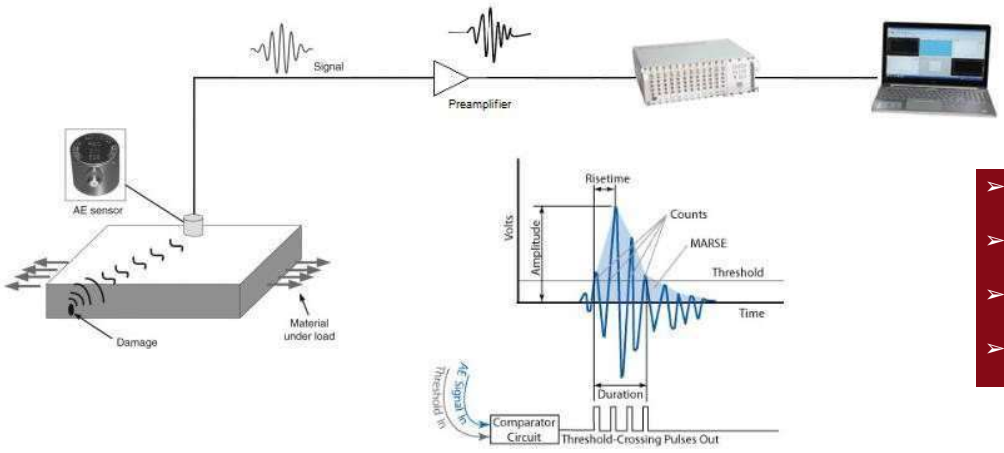
Acoustic Emission Testing – How this works

Acoustic Emission Testing □ Sismology
A 'passive' technique.



- Detection
- Recording
- Analysis
- Evaluation

6

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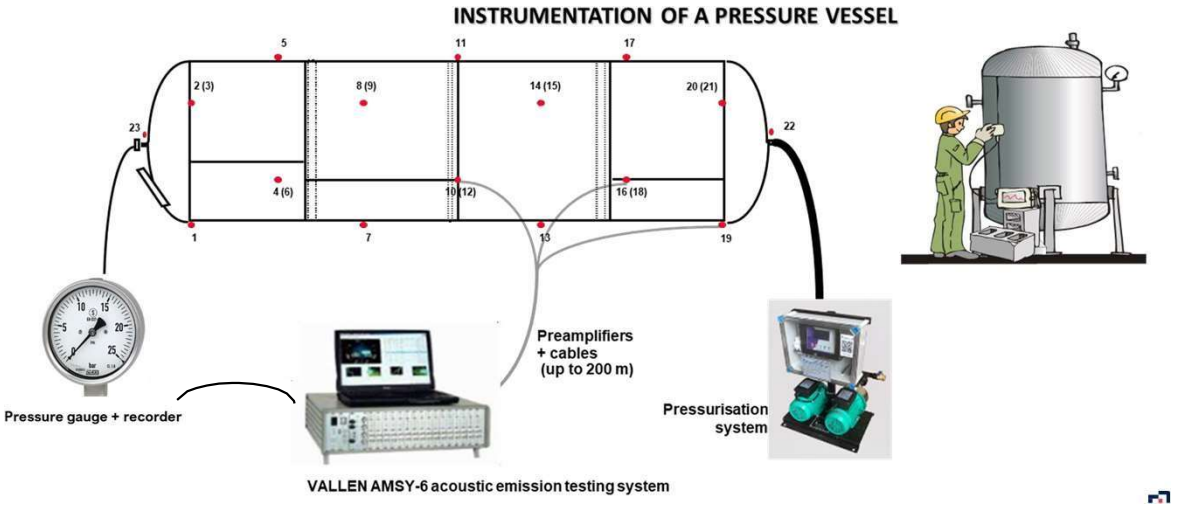
Acoustic Emission Testing – On site operations



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Acoustic Emission Testing - General aspects

Advantages

- **Global NDT** approach **enabling active flaw** localization
- **Real time dynamic** monitoring allowing **diagnosis** of the asset health status
- **Detect a range of damage mechanisms before they become significant issues** (corrosion, cracking, stress corrosion cracking, delamination, …)
- **A wide range of equipment can be covered** (storage tanks, chemical reactors, autoclaves, PSA, deshydatrators, pipelines…)
- **Has limited impact on equipment shutdown**
  - No need to empty the vessel
  - Insulation can remain in place
  - Use of the internal fluid or a neutral gas for pressurisation
  - Avoiding water use (vessel contamination)

AE contributes to maintenance cost savings

Limitations

- The defect **must be active** during the control (stressing) to be detected
- **The monitoring conditions must be compatible** with the phenomenon searched for. Proper preparation of the test is extremely important.
- AE signals attenuate as they propagate through the material, **limiting in some cases the detection range** of the technique.
- Acoustic emission testing does **not** make it **possible to determine the size of the defect**. Therefore, it is necessary to perform **additional NDT** to identify and size the defect.

Despite these limitations, AE remains a valuable NDT technique, especially when used in conjunction with other methods.

AE provides crucial insights into the integrity and health of materials and structures.

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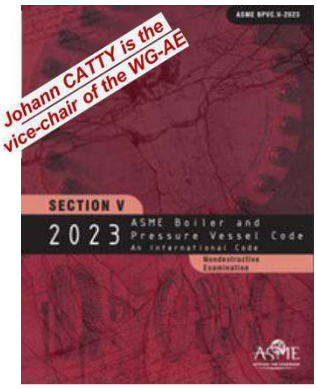
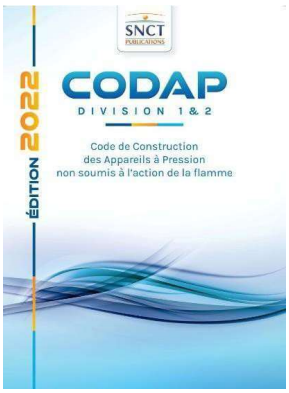
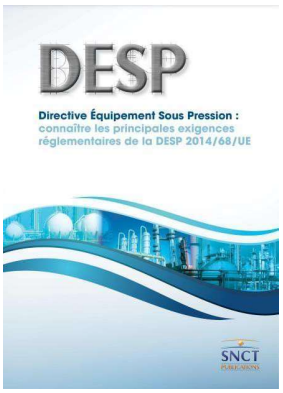
Acoustic Emission Testing
Codes and Standards – Pressure Vessels



Article 11 : AE examination of fiber-reinforced plastic vessels
Article 12 : AE examination of metallic vessels during pressure testing
Article 13 : Continuous AE Monitoring of pressure boundary components



French Code for construction of unfired pressure vessels



European Unfired pressure vessels

French Guideline for AET

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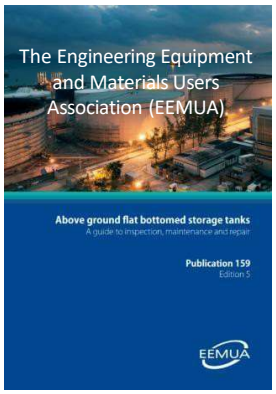
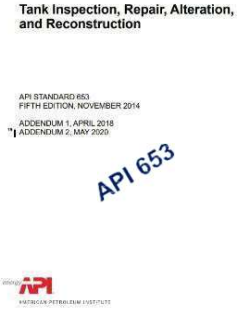
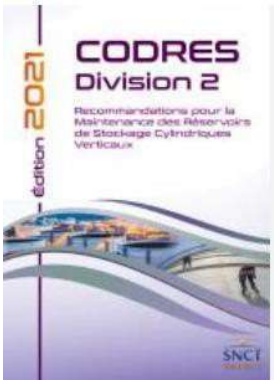
Acoustic Emission Testing
Codes and Standards – Aerial Storage Tanks



Guide for Inspection, Maintenance and Repair of above ground aerial storage tanks





French Code for maintenance of abovegroundaerial storage tanks

French Guideline for AET

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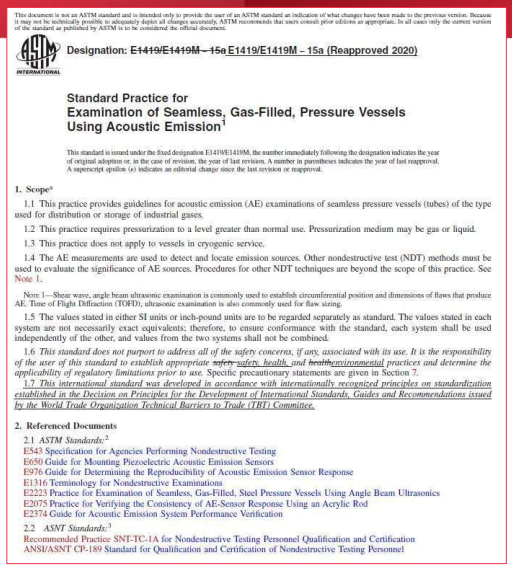
Acoustic Emission Testing
Codes and Standards – Seamless Gas-Filled, Pressure Vessels



This document is not an ASTM standard and is intended only to provide the user of an ASTM standard an indication of what changes have been made to the previous version. Because it may not be technically possible to adequately depict all changes accurately, ASTM recommends that users consult prior editions as appropriate. In all cases only the current version of the standard as published by ASTM is to be considered the official document.

Designation: ~~E1419/E1419M – 15a~~ E1419/E1419M – 15a (Reapproved 2020)

Standard Practice for Examination of Seamless, Gas-Filled, Pressure Vessels Using Acoustic Emission[1]

This standard is issued under the fixed designation E1419/E1419M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope[3]

1.1 This practice provides guidelines for acoustic emission (AE) examinations of seamless pressure vessels (tubes) of the type used for distribution or storage of industrial gases.

1.2 This practice requires pressurization to a level greater than normal use. Pressurization medium may be gas or liquid.

1.3 This practice does not apply to vessels in cryogenic service.

1.4 The AE measurements are used to detect and locate emission sources. Other nondestructive test (NDT) methods must be used to evaluate the significance of AE sources. Procedures for other NDT techniques are beyond the scope of this practice. See Note 1.

Note 1—Shear wave, angle beam ultrasonic examination is commonly used to establish circumferential position and dimensions of flaws that produce AE. Time of Flight Diffraction (TOFD), ultrasonic examination is also commonly used for flaw sizing.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 7.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]
E543 Specification for Agencies Performing Nondestructive Testing
E650 Guide for Mounting Piezoelectric Acoustic Emission Sensors
E976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response
E1316 Terminology for Nondestructive Examinations
E2223 Practice for Examination of Seamless, Gas-Filled, Steel Pressure Vessels Using Angle Beam Ultrasonics
E2075 Practice for Verifying the Consistency of AE-Sensor Response Using an Acrylic Rod
E2374 Guide for Acoustic Emission System Performance Verification

2.2 *ASNT Standards:*[3]
Recommended Practice SNT-TC-1A for Nondestructive Testing Personnel Qualification and Certification
ANSI/ASNT CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel

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Acoustic Emission Testing
Codes and Standards – Other fields of application

Organizations issuing Codes, Standards, Practices or Guidelines for Acoustic Emission, with Abbreviation and Web Site:

1 Association Française des Ingénieurs en Appareils à Pression (A.F.I.A.P.), (www.afiap.org) 2
2 American Gear Manufacturer Association (AGMA), (www.agma.org) 2
3 American Petroleum Institute (API), (www.api.org) 2
4 American Society of Mechanical Engineers (ASME), (www.asme.org) 2
5 American Society of NDT (ASNT), (www.asnt.org) 3
6 American Society for Testing and Materials (ASTM), (www.astm.org) 3
7 Australian Standard, Australia (www.standards.org.au) 5
8 Committee on Acoustic Emission from Reinforced Plastics, Society of Plastics Industry (CARP/SPI), USA, (www.socplas.org) 6
9 Comité Européen de Normalisation (CEN), Belgium, (www.cenorm.be) 6
10 Electric Power Research Institute (EPRI), USA, (www.epri.com) 7
11 European Committee for Electrotechnical Standardization, (CENELEC), (www.cenelec.eu) 8
12 Institute of Electric and Electronic Engineers (IEEE), USA, (www.ieee.org) 8
13 International Institute of Welding, (IIW), (www.iiwelding.org) 8
14 International Organisation for Standardisation (ISO), Switzerland, (www.iso.ch) 8
15 Japanese Industrial Standard (JIS), Japan, (www.jsa.or.jp) 9
16 Japanese Society for Non-Destructive Inspection (JSNDI), Japan (www.jsndi.jp) 9
17 National Aeronautics and Space Administration (NASA), (www.nasa.gov) 9
18 National Association of Corrosion Engineers (NACE), USA, (www.nace.org) 10
19 Technischer Überwachungsverein (TÜV), DE, (www.tuev-verlag.de/ProduktVerz/tabvd005.htm) 10
20 United Kingdom Health & Safety Executive (HSE), UK (www.hse.gov.uk) 10

3 American Petroleum Institute (API), (www.api.org)

Term	Title	Edition	Comment
ANSI/API 510	Pressure vessel inspection code: Maintenance inspection, rating, repair and alteration (Section 6.4 "External Inspection")	2006	pressure vessel
API SPEC 16A	Specification for Drill Through Equipment	2004	quality assurance drilling machine

4 American Society of Mechanical Engineers (ASME), (www.asme.org)

Term	Title	Edition	Comment
ASME	Boiler and Pressure Vessel Code Section V, Article 11, Acoustic Emission Examination of Fiber Reinforced Plastic Vessels	2001	pressure vessel, fiber reinforced plastic vessels
ASME	Boiler and Pressure Vessel Code Section V, Article 12, Acoustic Emission Examination of Metallic Vessels During Pressure Testing	2001	pressure vessel, metal
ASME	Boiler and Pressure Vessel Code Section V, Article 13, Continuous Acoustic Emission Monitoring	2001	Monitoring, metal, non-metal
ASME	Boiler and Pressure Vessel Code Section V, Article 29, Acoustic Emission Standards	2001	See ASTM E 650-97, E 976-98, E 1211-97, E 1419-96
ASME	Boiler and Pressure Vessel Code Terminology for Nondestructive Examinations Standards, 5. Acoustic Emission	2001	See ASTM E 1316-99
ASME	Boiler and Pressure Vessel Code Section VIII, Division 1, Case No. 1968 Use of Acoustic Emission Examination in Lieu of Radiography	1985	pressure vessel valid until 1991, might be not valid

Some examples

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Acoustic Emission

Steps involved

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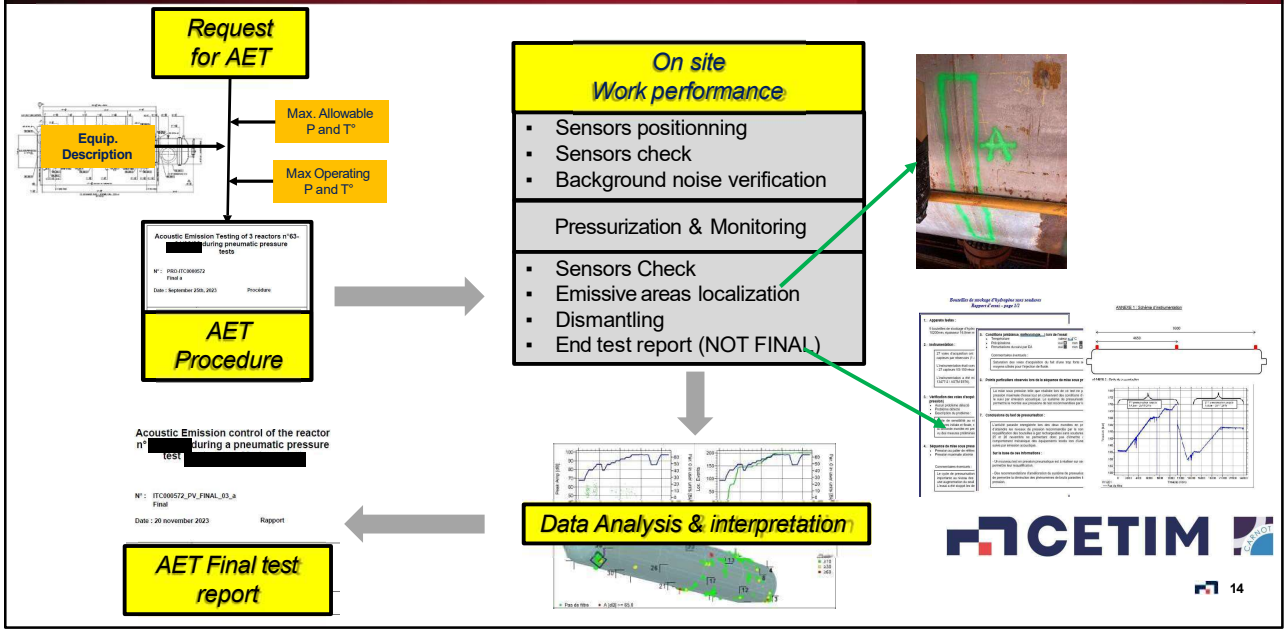
Acoustic emission testing : Steps Involved – Pressure Vessels



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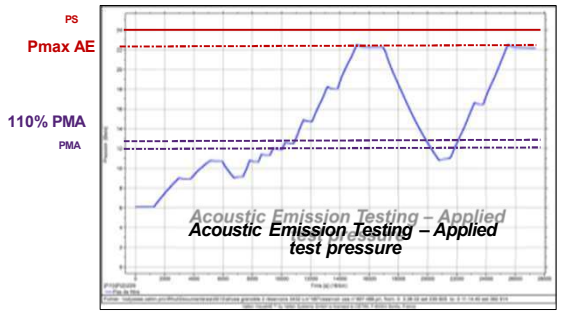
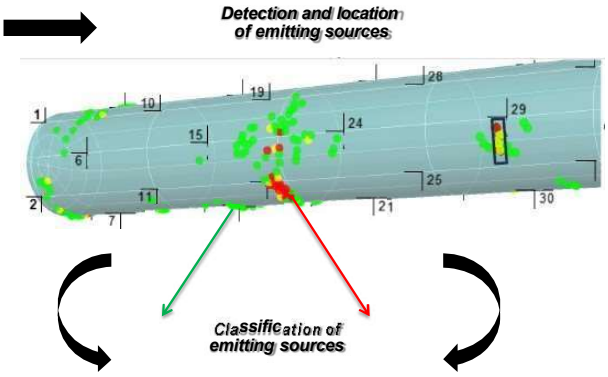
Acoustic Emission Testing
Major steps – Pressure Vessels



Conditions to comply with

- **Technical conditions**
  AE testing pressure > 10% of the maximum working pressure in service (PMA)
- **Regulatory conditions**
  Acoustic emission testing pressure > 110% PS in many countries (> 90% PS (for France);



Base on detailed analysis of acoustic emission Vs criteria defined in codes and standards

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Acoustic emission testing : Results reporting Pressure Vessels

Analysis and data interpretation (depending on local regulations/rules)

- Acoustic emission sources observed during the test are classified according to their severity :
  - Category 1: **No further action are required** but are included in the AE test report for the future tests.
  - Category 2: **Further investigations are recommended**. There may be a doubt about the harmfulness of the indication. The origin of the source must be clarified by further analysis (taking into account additional data, Supplementary Examination by NDT)
  - Category 3: Sources and / or critical areas should be subject to further investigations; **further examination by NDT is imperative before the restart of the equipment.**
- Areas and/or AE sources in categories 2 or 3 will be marked on the equipment at the end of the pneumatic test.

Final control report

- General information : Equipment identification, date, purpose, applicable documents (procedure, specifications, codes/standards,…)
- Maximum pressure test value, Operating conditions (mapping of the position of the sensors, pressure cycle, filling procedure, type of fluid used)
- Position of the main areas of discontinuities on a diagram of the structure
- Data analysis of acoustic emission
- Interpretations of the results with the localization and the relative severity of significant acoustic emission sources
- All the criteria for the classification are indicated.
- Conclusions and suggestions
- Name, qualification and certification of operators Level 2 (writer and reader officer Level 3
- …

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Acoustic emission testing : Example

(Refer to 220-ALV-300)

Final control report :

- **Content is important :**
  - AET can bring information on the evolution of the activity (potential defects) from one AET control to the previous/next one
  - AET controls should be performed as similarly as possible

- **Has to comply with the requirements of the standards :**
  - Crucial informations are required
    - Attenuation curve
    - Sensitivity of the channels
    - Localization performance
    - Background noise evaluation,
    - …

Cannot be as short as a Magnetic Particle Inspection report !

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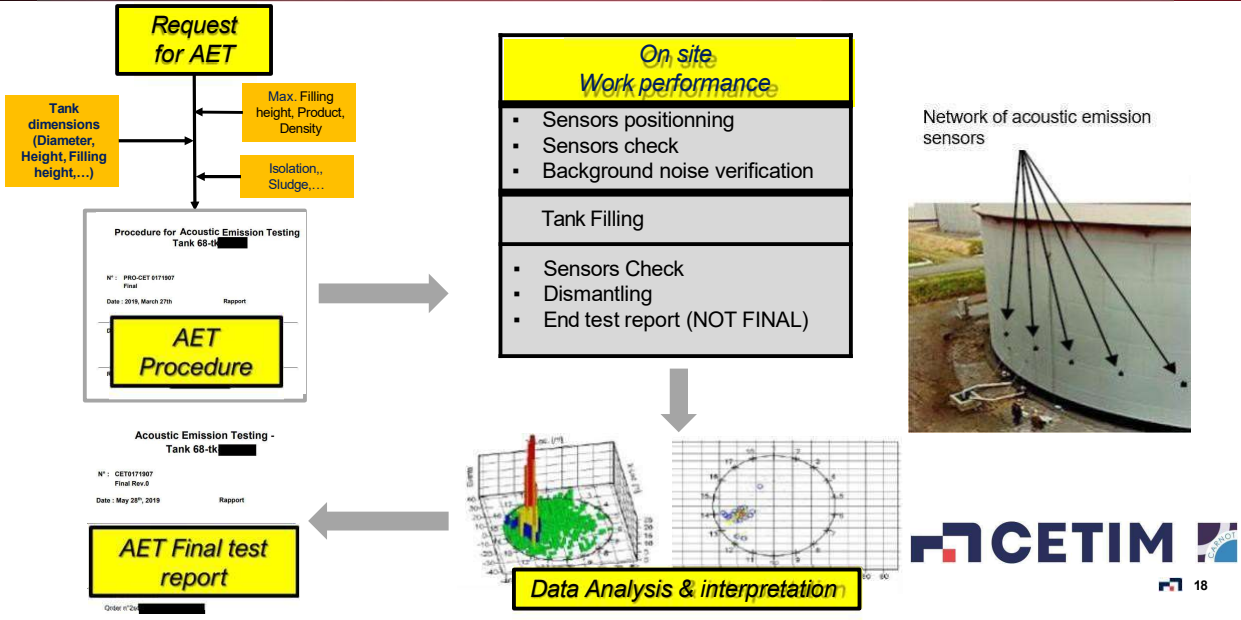
Acoustic emission testing : Steps Involved – Storage Tank



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Example

. 12 meters diameter
- Fuel
- 20 sensors have been installed

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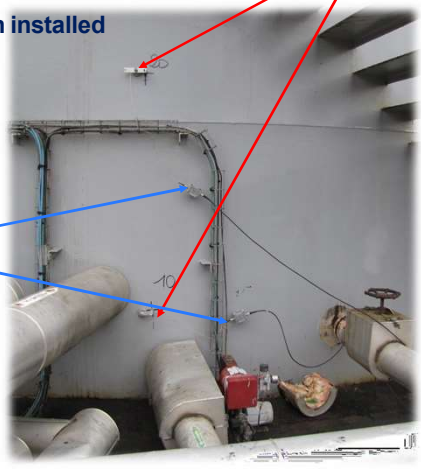
Example

. 12 meters diameter
- Fuel
- 20 sensors have been installed



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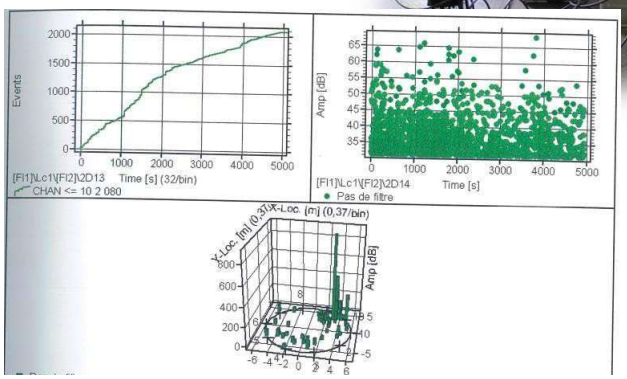
Example

. 12 meters diameter
- Fuel
- 20 sensors have been installed
- Duration of the recording : 1h23 min. (minimum is 1h.)



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Acoustic emission testing : Results reporting Aerial Tanks

Analysis and results reporting (UFIP Guide example)

"Average amplitude" criterion (dBea)

"Event density" criterion (ev / hr / m²)	30 to 40	40 to 50	50 to 60	60 to 70	>70
< 5	A	B	B	C	C
5 to 10	A	B	C	C	D
10 to 15	B	C	C	D	D
15 to 20	B	C	D	D	E
> 20	C	D	D	E	E

Criteria for the classification of the general corrosion condition

Class	Condition of the bottom floor
A	Good
B	Minor damage
C	Intermediate damage
D	Significant damage
E	Major damage

Classification of the overall active corrosion condition

"Average amplitude of the cluster" criterion (dBea)

"Activity in the cluster" criterion (ev / hr)	30 to 40	40 to 50	50 to 60	60 to 70	>70
< 10	0	1	2	2	3
10 to 50	1	1	2	3	3
50 to 100	2	3	3	4	4
100 to 500	3	3	4	4	5
> 500	3	4	4	5	5

Leak probability class criterion

Classification of the storage tank (Letter + Number)

AE on storage tanks is reliable for corrosion and/or leak detection on area between the shell and 25 m from the shell to the center.

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Example

. 12 meters diameter

- Fuel
- 2 analysis :
  - Probability of corrosion : based on activity (events) (in this case, B)
  - Probability of leak : based on clustering (concentration of localized activity) : level 0 to 5 (in this case, 2, meaning low risk of leak). This analysis is described by a cartography of the bottom

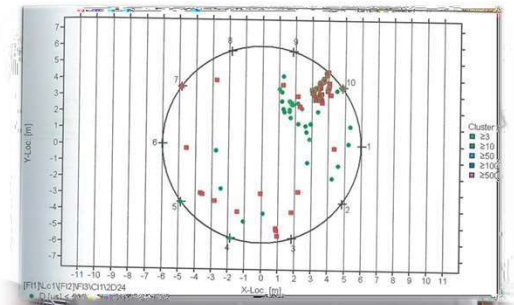

Tableau 5: Echéance recommandée (ans) avant prochaine inspection hors service en l'absence de méthodologie RBI

classes	a	b	c	d	e
0	10	10	7	3	2
1	10	10	3	2	1
2	10	5	2	2	1
3	5	5	2	1	0
4	2	1	1	0	0
5	0	0	0	0	0

Recommandation of 5 years
Until the next AET

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Acoustic Emission

Markets and Applications

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PSA (Adsorbers / Gas purification)

Use

- Purification of industrial gases (H_2, Ethanol, …)

Advantages in applying AET

- Avoid to empty the vessels for internal inspection and/or hydraulic pressure test : Some products (Zeolite ie) inside are very expensive
- AET is easy to apply, and fast
- Drastically reduce the duration of the maintenance, therefore increasing the productivity
- Gives an accurate diagnosis of the health state / fitness-for-service

Codes/regulation

- EN-14584
- ASME Section V – Art. 12
- French Application Guide – Annex 6 /10

❖ **gas pressurization with an Inert gas is possible**
Simultaneous AET of 2 or more PSA is possible

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Reactors / Fleaters

Use

- Process of minerals refining

Advantages in applying AET

- Avoid to empty the vessels for internal inspection an[d] hydraulic pressure test : safety issues (acid product[s])
- Avoid to remove external insulation
- Structure is complex (important thickness + clad + li[ne]
- AET is easy to apply, and fast
- Drastically reduce the duration of the maintenance, therefore increasing the productivity
- Gives an accurate diagnosis of the health state / fitn[ess] for-service

Codes/regulation

- EN-14584
- ASME Section V – Art. 12
- French Application Guide – Annex 6 /10

❖ **gas pressurization with an Inert gas is possible**

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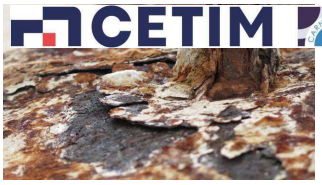
Reactors / Fleaters – example of result



Corrosion under insulation discovered thanks to AET

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H_2S Reactor

Use

- Production of H_2S

Advantages in applying AET

- Avoid to empty the vessels for internal inspection and/or hydraulic pressure test : safety issues (acid products)
- Avoid to remove external insulation
- Structure is complex (important thickness + insulation)
- AET is adapted to the potential degradation mechanisms
- Drastically reduce the duration of the maintenance, therefore increasing the productivity
- Gives an accurate diagnosis of the health state / fitness-for-service

Codes/regulation

- EN-14584
- ASME Section V – Art. 12
- French Application Guide – Annex 6 /10/8

❖ **gas pressurization with an Inert gas is possible**

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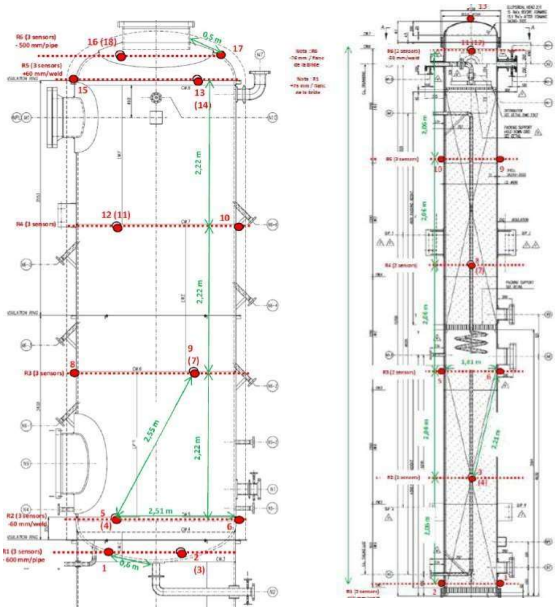
H_2S Reactor

- 2 pressure vessels controlled in one operation



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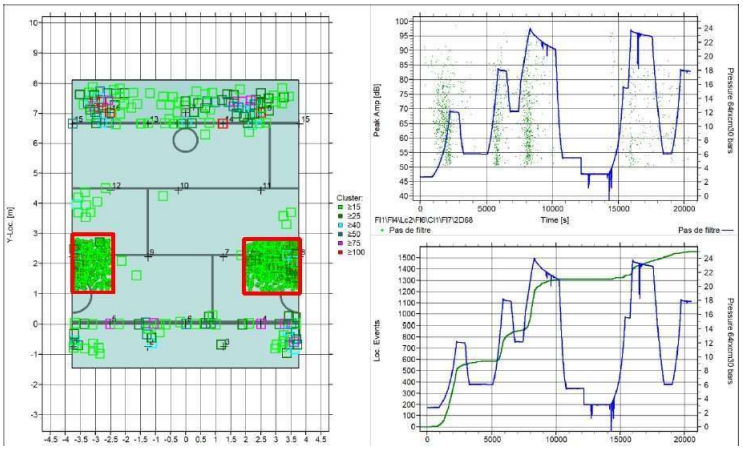
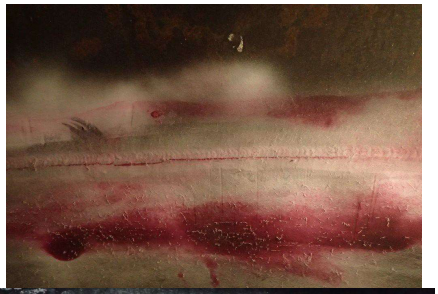
H_2S Reactor

- 2 pressure vessels controlled in one operation





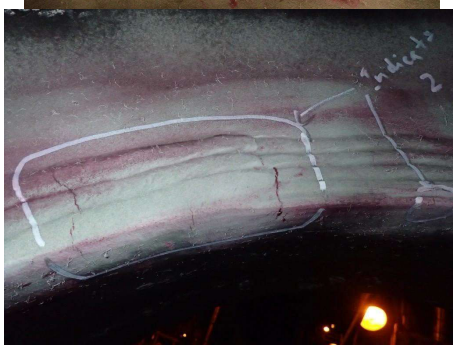


Figure n°8c: Area 'B' close to c8 sensor (N9 nozzle) (category 2)

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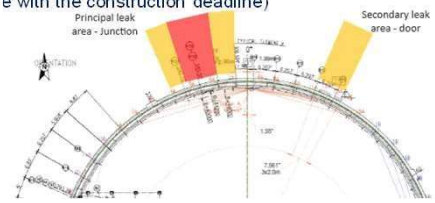
LNG Tank
Checking leak tightness by Acoustic Emission

Use & Context

- LNG storage and distribution (190 000 m³. Dim 90 m x 50 m)
- Air pressure test after construction revealed leak tightness defects somewhere in the metallic liner

Advantages in applying AET

- Acoustic Emission as a global CND technique allow to identify defects areas where further local inspections can be performed
- Areas of defects localized (principal □ junction of a pipe and the liner)
- Brought response in a very short delay (3 days), compatible with the construction deadline)



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Assessing integrity and repairability

Use & Context

- Spherical storage of LPG (4 000 m³)
- Carry out a global diagnosis of the storage sphere after flaws detection on welded area

Diagnosis carried out

- Overall acoustic emission test carried out to determine areas with flaws likely to grow
- Advanced NDT (TOFD/PAUT) to characterize detected defects
- "Boat shaped" type sample taken to understand root cause leading to flaws
- Welding repair procedure drafted.
- NDT carried on repaired areas
- Qualification of the equipment

Codes/regulation

- EN-14584
- ASME Section V – Art. 12
- French Application Guide – Annex 3

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Gas storage tanks under embankment

Use & Context
- Spherical / Cylindrical storage tanks
- Under embankment (no more access to the vessel surface)

AET
- Use of waveguides technology
- CETIM has developed this technology end of 90's
- A strong return of experience (necessary)

Codes/regulation
- EN-14584
- ASME Section V – Art. 12
- French Application Guide – Annex 6
- CODAP French Guide

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Gas storage tanks under embankment

Use & Context
- Spherical / Cylindrical storage tanks
- Under embankment (no more access to the vessel surface)

AET
- Use of waveguides technology
- CETIM has developed this technology end of 90's
- A strong return of experience (necessary)

Codes/regulation
- EN-14584
- ASME Section V – Art. 12
- French Application Guide – Annex 3

Gas storage spheres under sarcophagus (with wave guides)

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Autoclaves

Use

- Aerospace industry (composite structure providers), Composite industry in general, Glass industry, Food industry, …
- Small to large (1 m^3 to > 200 m^3)

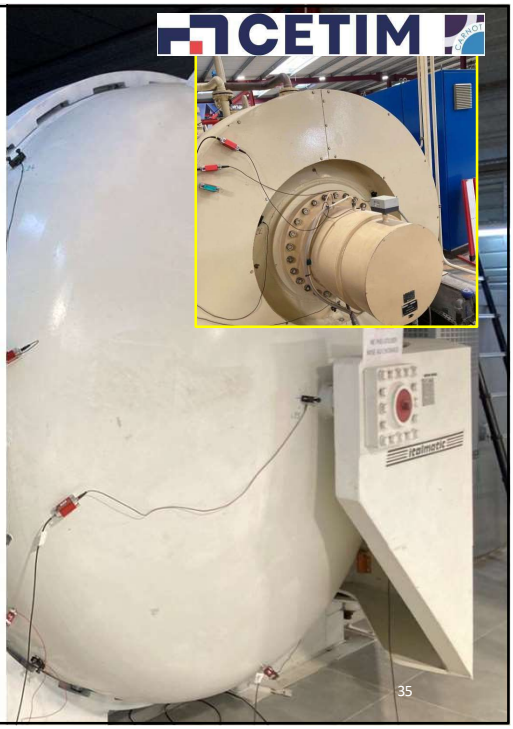
Advantages in applying AET

- No dismantling (inside : insulation, thermal resistances, vacuum connexions, heat exchanger, ..).
- Autoclaves with external insulation can be done without removing the entire insulation
- AET is able to check the whole structure (including door and locking system)
- Drastically reduce the duration of the maintenance therefore increasing the productivity of the equipment
- Gives an accurate diagnosis of the health state / fitness-for-service

Codes/regulation

- ASME Code Section V / Article 12
- French Application Guide – Annex 9 (specific for Autoclaves)
- EN 14584 / EN 15495

❖ **Requires a good preparation (leaks could disturb AET)**
❖ **AE sensors placement requires experience / feedback**



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Autoclaves

CETIM

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Seamless Gas-Filled Pressure vessels (metallic)

Use

- Distribution or storage of industrial gases

Advantages in applying AET

- Avoid to empty the vessels for internal inspection and/or hydraulic pressure test
- AET is easy to apply, and fast
- Drastically reduce the duration of the maintenance, therefore increasing the productivity
- Gives an accurate diagnosis of the health state / fitness-for-service

Codes/regulation

- EN-ISO 16148
- ASTM E1419 (2020)
- French Application Guide – Annex 12 (in progress)

❖ **Sometimes, gas pressurization is a challenge (helium)**

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Hyperbaric chambers

Use

- Hospitals / Military

Advantages in applying AET

- Complex structures in terms of shape
- Avoid to remove internal instrumentation and accessories
- Drastically reduce the unavailability (typically, from 2 weeks to 1 or 2 days)
- Gives an accurate diagnosis of the health state / fitness-for-service

Codes/regulation

- EN-14584
- French Application Guide – Annex 6

❖ **CETIM is the 1st to perform AET on this type of structure**

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Linear Accelerators

Use

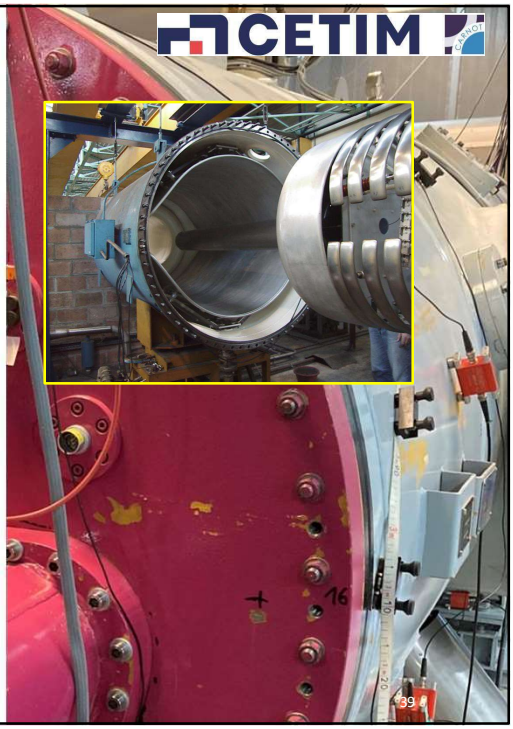
- Laboratories dealing with Particles Acceleration, also in high-tech industries (cables, electronics, …)
- Contain SF6 gas (expensive/nocive for environment)

Advantages in applying AET

- Avoid any dismantling of the machine (very fragile elements inside)
- Avoid SF6 gas loss
- Drastically reduce the duration of the maintenance, therefore increasing the productivity of the machine
- Gives an accurate diagnosis of the health state / fitness-for-service

Codes/regulation

- ASME Code Section V / Article 12
- French Application Guide – Annex 6
- EN 14584 / EN 15495



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Sterilizer / Freeze Dryer

Use

- Hospitals / Pharmaceutic industry / Food industry

Advantages in applying AET

- Complex structures with double wall envelop + insulation => Diagnosis of the resistant wall is impossible from the outside
- Avoid to remove external insulation
- AET requires specific application procedure (stainless steel)
- Drastically reduce the duration of the maintenance, therefore increasing the productivity
- Gives an accurate diagnosis of the health state / fitness-for-service

Codes/regulation

- EN-14584
- French Application Guide – Annex 6 /10

❖ **AET can be now integrated into the conception of the sterilizer (waveguides)**

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CETIM
Heat Treatment Furnaces

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Health
Mining
CETIM
Oil&Gas
S104-GPL
S105-BUT
Heat treatment
Food & Beverage
Some other Markets
42

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Acoustic Emission

A monitoring technique

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Building on experience, integrating technological developments

Acoustic Emission

- A physical phenomenon defined by the **creation of transient elastic waves** resulting from multiple mechanisms: plastic deformation, propagation of cracks, erosion, corrosion, impact, leakage, cavitation, ...
- Is therefore by nature a **monitoring technique**. It is intimately linked to the behavior of the structure subjected to a stress (mechanical, thermal, chemical, ...)
- Is one of the rare techniques **to be able to detect** source phenomena **in real time**

❖ **Very high potential technique in the field of Structural Monitoring**

❖ **A technique that must adapt and take into account the environment of the structure**

❖ **More than other techniques, requires strong expertise**

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