NEW EDITION OF GEA GUIDELINE FOR ACOUSTIC EMISSION TESTING OF PRESSURE EQUIPMENTS

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Abstract:

To master over time the integrity of the equipment and ensure operational safety, in service inspections are carried out periodically in compliance with regulatory requirements and / or professional rules of supervision.

Acoustic emission now performed industrially for more than thirty years, is currently the only technique which, when applied in a suitable methodology enables to control an equipment in a global way regardless of the nature of damage that could be identified.

The AFIAP, only national entity bringing together the main parties involved in the pressure equipment: administration, manufacturers, users, technical centers, notified bodies, NDT provider organizations, mandated to a working group called "Acoustic Emission Group " the development of a" good Practice Guide for the acoustic emission.

This guide, which is officially recognized by the French administration, incorporates the requirements of the available standards and the experience gained by the professionals of this method.

It consists of general basis and annexes, each relating to a family of equipment. It is applicable in the context of the French legislation for the in-service monitoring of pressure equipment.

Previous editions of this guide were published in 2004 and 2009 with an enlargement to new annexes.

This new edition which is the subject of this presentation, takes into account the feedback over all these years of use and integrates new additional annexes, allowing extending the scope of this requalification method.

1. Introduction

Acoustic emission is a test technique that, when practiced according to a controlled and appropriate methodology, makes it possible to control globally an equipment regardless of its dimensions and its location. It is practiced now for more than thirty years and has been used on thousands of pressurized equipment of the oil, chemical, energy, ... The experience gained allows to have a great confidence in the information provided.

AFIAP - the only national entity including the five parties involved in pressure equipment: administration, manufacturers, users (represented in particular by UFIP and UIC), technical centers, non-destructive testing organizations - has developed, with the support of the French Administration, and maintains a "Guide to Good Practices for Acoustic Emission" (GBP).
2. The practice of acoustic emission on pressure equipment

For more than 30 years acoustic emission tests have been performed on pressure vessels. They were first selected as a global control method during hydraulic tests and then, on a case-by-case basis, in the context of derogations, during pneumatic tests carried out in substitution of hydraulic re-proof test.

In the past, the requests made to the administration were made most often when a re-hydraulic proof test leads to heavy constraints on the equipment or when the test was impossible (structures not designed to take over the overloads induced by the hydro proof test, equipment apparatus that cannot be drained and dried completely, etc.) or when the overall cost induced by a re-test was industrially, economically excessive. The results obtained were quickly encouraging for several reasons: the test, as previously reported, makes it possible to obtain information on the globality of a structure, the sensitivity of the test is great, the test can be carried out during a "simple" process or pneumatic fluid pressurization, the overload being limited to 10% of the maximum pressure seen by the equipment during the last 6 to 12 months of operation, the test requires the immobilization of the equipment only a limited time most often to one or a few days depending on the complexity of the equipment and that of the implementation of the test.

However, the practice of acoustic emission has been limited by:
- the need for expensive test equipment,
- few operators on the market, although now more and more providers are entering the field of activity,
- the limited experience of his practice a few years ago,
- the absence of implementation benchmarks recognized by the professions and the administration,
- the imposition of passage of applications for exemptions in Central Commission of Pressure Devices (CCAP).

The oil, gas, chemical and energy industries wished to develop (but not generalize) the application of this test method, particularly because of the openness offered by the new pressure equipment regulations relating to the operations to be carried out within the framework of the requalifications: decree of 15 March 2000, title V, article 23 § 7 and 8 "Decisions taken after opinion of the CCAP, may provide that the hydraulic test be replaced by another test resistance under pressure ... that the periodic requalification be replaced by any other method which guarantees an equivalent level of safety."
2.1 Position of the administration

In order to be able to give confidence in the practice of testing the pressure equipment, the administration wished that a frame of reference covering all the stages that mark its implementation be drawn up by the actors concerned: Bureau of Risk and Network Equipment (BSERR), manufacturers, service providers, technical centers. This led to the creation of the Acoustic Emission Group (GEA) presented in § 1 and the drafting of the "Good Practice Guide for Acoustic Emission" (GBP) within AFIAP.

The GEA has produced a first version of the guide to the rules of good practice for acoustic emission in July 2001 (2001 edition) which was the subject of Ministerial Decisions DM-T / PN 32255 of 26 September 2002 and DM-T / PN 32460 of 1 April 2003.

A second version of the guide has been produced (May 2004 edition); it was the subject of Ministerial Decision DM-T / P N e° 32970 of May 28, 2004. This edition has been translated into English.

The revised Annex 4, relating to liquefied petroleum gas storage tanks (LPG) called "small bulk" was approved by the BSEI 05-442 of 23 December 2005. The annex 8 relating to the reactors (vessels in which occur chemical reactions) was approved by BSEI decision n° 07-107 of April 13, 2007.

A third edition of the GBP took place in 2009. It was the subject of the BSEI decision N° 09102 of June 29, 2009 (modified by the BSEI n° 11110 of October 5, 2011). Since then, annex 10 concerning stainless steel equipment has been validated by the BSEI decision N°13-009 of 17/01/2013 as well as appendix 7 on the equipment in composite materials by the decision BSEI N° 14079 of 4 July 2014 and Annex 11 on exchangers by BSEI decision N°14110 of 31 October 2014.

This edition 2009 has been translated in English with the name “Guideline for acoustic emission testing of pressure equipment". [1]

Recently a new edition has being published in 2016 and released from the beginning of 2018 in computer form. It was validated by the BSERR decision N°16-034 of February 23, 2016.

Thus, any application, filed by an industrialist, to the requalification requirements, such as the replacement of a hydraulic re-proof test by a pneumatic test with acoustic emission monitoring in accordance with the requirements of the GBP and its annexes, may be treated at the level of the Authorized Organizations without passing through the DREAL or at the level of the CCAP.

3. The guide to Good Practices for Acoustic Emission

3.1 Constitution of the guide

The guide consists of a general part, applicable to all acoustic emission tests performed on ESPs, called "body of the guide", then appendices, each applicable to a family of equipment that defines the specificities of the Acoustic Emission attached to the family, including criteria and thresholds for interpretation of recorded data.
The body of the guide contains the chapters indicated in appendix 1.

### 3.2 Working methodology for guide development

The GEA is a group of about 30 representatives from the five entities involved: BSERR, manufacturers, users, service providers, technical centers. This group gives instructions for the work to be done and validates the documents. It is led by a user representative and its secretariat is provided by a technical center.

### 3.3 The body of the guide

It had been written by two "colleges".

- The "college 1" composed of representatives of the administration, the manufacturers, the users and the CETIM wrote the general chapters and those concerning the service provider / principal / inspection links,

- The "college 2" composed of representatives of the service providers, the technical centers wrote the chapters concerning the practice of the test and the interpretations of the recordings

### 3.4 Annexes

The first two appendices are general:
1. Standards, codes, regulatory texts,
2. Examples of equipment controlled by acoustic emission

Each of the following appendices is applicable to a family of equipment. They complete the body of the guide as to the modalities of the test and the interpretation of the results.

The available annexes concern respectively:

3 Methodology to be used for the elaboration of a procedure applicable to spheres
4 Methodology to be used to develop a procedure for underground "small bulk" LPG tanks
6 Methodology to be used to develop a procedure for cylindrical ESPs
7 Methodology to be used for the development of a procedure for composite material equipment
8 Methodology for the development of a reactor procedure
9 Methodology to be used to develop a procedure for autoclaves
10 Methodology for developing a procedure for stainless steel equipment
11 Methodology to be used for the development of a procedure for exchangers

The summary of these appendices is based on that of the guide body.
3.5 Working methodology for the preparation of an Annex

For a new family of equipment concerned, a first file must have been approved in CCAP. Two other files made on the same basis must also have been approved by the administration. These tests are the subject of a feedback analysis.

The decision to create a new annex is made by the GEA in plenary session. For each new annex, a working group of experts composed of representatives of service providers and users having practiced this type of acoustic emission tests on the family of equipment concerned is constituted.

Other appendices applicable to new families of equipment may be commissioned by industrial or professional unions.

The working group, led by a user, develops a draft annex. The convenor of the working group informs the GEA in plenary session of the progress of work. In the event of a blockage or technical difficulty, the assistance of a third-party expert can be requested from the GEA.

The project is then forwarded to the members of the GEA, accompanied with the Acoustic Emission Guide modification sheet and all supporting documents for approval of this annex.

The GEA plenary examines this project and decides to approve it after incorporating any minor adjustments or to return it to a working group for finalization.

Once approved by the GEA, the project, the modification sheet and the supporting documents are forwarded to the BSERR by the AFIAP President, for instruction and transmission to the CCAP for approval.

Between the various editions of the guide of intermediate evolutions (body of the guide, new appendix or revision of an existing appendix) can be subject to validation by the GEA and recognition by the Administration. As soon as they are recognized, these changes are made available to the users of the guide.

3.6 New Annexes available

Three new annexes have been included in the new edition of the 2016 guide.

• Annex 7: Methodology to be used for the development of a procedure for composite equipment

Composite ESPs are generally composed of a strong structure made from resin impregnated fibers, deposited around a sealing liner.

These structures are intrinsically heterogeneous, and their degree of anisotropy depends on the orientation of the fibers and the stacking of the various layers constituting the composite structure. This anisotropy will have an influence on the propagation of acoustic emission waves.

The acoustic emission produced by a composite material structure depends on many factors such as material components, laminate composition, manufacturing process, geometry and ambient conditions during the test. The interpretation of acoustic emission results will therefore depend on the knowledge and consideration of these various factors.
With this observation, it appeared that for a composite materials ESP, the performance of the pressurization tests and the data processing must be adapted to the specificities of the composite materials while following the practical recommendations described in the Guide of Good Practices for the control by Acoustic Emission, 2nd edition 2009 (GBPEA). Specific criteria were developed based on the experience gained by the members of the working group.

Working Group 7 of the GEA has therefore focused its work on the drafting of a specific annex for ESP in composite materials.

Initially it was planned to deal with two parts in the scope of the annex:

- Annex 7a concerning equipment operating at low pressure (<10 bar) and atmospheric tanks
- Annex 7b concerning pressure equipment.

Following the observation of the BSERR that the atmospheric tanks do not fall within the regulatory framework of the decree of March 15, 2000, the WG decided to devote first to the drafting of the section concerning pressure equipment.

Another point was raised in terms of "transportable" pressure equipment, which is covered by the amended decree of 29 May 2009 on the transport of dangerous goods by land (known as the TMD) which refers directly to the texts of international agreements on the transport of dangerous goods (RID / ADR / ADN). The ADR already provides the possibility to replace the hydraulic test of the periodic regulatory inspection by AE monitoring of a pneumatic test.

Despite the peculiarities of this fixed pressure equipment made of composite materials, this Annex 7 is as accurate and homogeneous as the other types of equipment already approved under GBPEA.

Annex 10: Methodology for the development of a procedure for stainless steel equipment

Tests and expertise show that stainless steels behave similarly to low-alloy steels with a lower emissivity and a generally higher attenuation.

This appendix for stainless steel equipment therefore proposes that:

- the carrying out of the pressurization tests follows the same treatment principle as for non-alloy steel equipment, i.e. the provisions with annexes already approved of the Guide to Good Practice for Acoustic Emission;

- some parameters are adapted to guarantee the objectives of the tests (thresholds and reference criteria).

The logic adopted by the GEA was therefore not to complete the existing annexes but to draft an annex common to all stainless steel ESPs.

For the development of a procedure for stainless steel ESPs, it is therefore appropriate to use Annexes 3, 6, 8 and 9 of the guide, respectively supplemented with the recommendations described in Annex 10.

- Annex 11: Methodology to be used to develop a procedure for interchanges
The exchangers are similar for the common parts (shells, bottoms, nozzles, etc.) to the other pressure equipment, the specific parts being the tube plates and the bundle. The tests and the expertise carried out show that the AE diagnosis is feasible on the tube plates; on the other hand, as far as the bundle is concerned, the state of the art so far does not completely cover this part even if information can be used on a case-by-case basis during the test.

As a result, the scope of this annex is limited to the parts covered by acoustic emission without bundle. In the context of the replacement of the periodic requalification hydraulic test, other measures shall be provided by the operator for parts not covered by AE, with the prior approval of the Administration. These measures are not described in this annex, which only concerns AE.

With these observations, it appeared that for a given exchanger, the implementation of the AE should follow for most common parts (shells, funds, nozzles ...), similar recommendations to those of Annex 8 " reactors "already approved of the Guide of Good Practices for the control by Acoustic Emission, 2nd edition 2009.

The drafting of this self-supporting appendix deals with the particularity of heat exchangers, especially for tube plates, and requires the AE test while the shutdown of the equipment.

This appendix is intended to be as accurate and homogeneous as those of the other types of equipment already approved and allows to frame the AE of the exchangers for the parts covered by the diagnosis.

4. Organization of feedback

Feedback is managed by Feedback Working Group and is carried out annually using two sheets to be completed by each user, a summary sheet and a detailed sheet that collects the essential characteristics of equipment controlled according to the GBP guide as well as the main results of the acoustic emission.

The objective is to identify the key points, the possible problems encountered, and the solutions chosen. Through the lessons learned from the experience described, these sheets can generate modification sheets of the guide.

These experience feedback sheets are then grouped by type of annexes concerned in order to develop a synthesis that is sent each year to the Administration.

Till now, more than 22,000 feedback sheets have been received since the implementation of the GEA guide. These sheets are distributed in the different annexes as follows:

- Annex 3(spheres): 30
- Annex 4(small bulks): 21,618
- Annex 6(cylindrical vessels): 266
- Annex 7(composites vessels): 2
- Annex 8(reactors): 83
- Annex 9(autoclaves): 341
- Annex 10(inox vessels): 60
- Annex 11(exchangers): 22
In parallel, 126 change sheets have been studied and integrated in the last edition of the guide.

5. Conclusion

The working group of the GEA is still active within AFIAP, it meets in plenary session twice a year to follow the application of the guide and to take into account the feedback. This work led to the new edition of the 2016 guide which will be available for the first time in electronic version.

An English version will be available soon.

Bibliography: