Using a Data Base Tool for the efficient Administration of AE-Data

Hartmut Vallen, Jochen Vallen, Jens Forker, Gabriel Corneanu
Vallen-Systeme GmbH, Icking, Germany

1. Introduction

Modern AE equipment may acquire thousands of hits per second, analyse these data in a very fast, complex and comfortable manner, produce hundreds of diagrams, but at the end, if the user has no criteria how to assess these results, they are not much worth at that time.

If one has data from 10 similar test objects, those with known defects and those without a defect, he can systematically look for differences in the data and start to develop evaluation criteria for defect detection. There are different grading schemes possible, the following is an example for pressure vessel testing:

A) No indication: The AE test does not give any indication of a potential defect.
B) Minor source: The AE test provides indications for one or more minor sources, but no further actions shall be necessary.
C) Active source: The AE test provides indications for one or more potential defects and further NDT shall be recommended for specific parts of the pressure equipment, e.g. weld seams, attachments, etc..
D) Critically active source: The AE test provides severe indications for one or more localized defects and further evaluation by other appropriate NDT shall be carried out BEFORE the pressure equipment goes into service.

Grading criteria are used for real time control (e.g. to stop pressurization before any dangerous situation develops) and for subsequent source severity classification. According to prEN14584 (Proof testing of metallic pressure vessels), these criteria shall be defined by the AE test organization "on the basis of experience".

This "basis of experience" has once to be acquired and is often still "under development." A successful grading of an AE test object based on the acquired AE data was long time only the matter of well experienced experts. Nowadays, many testing organizations possess experience from testing hundreds or even thousands of pressure vessels of different sizes.

The today's experts, with 10, 20, or even more years of experience, represent a very important asset in form of intellectual property. In order to maintain this property they have to transfer their knowledge to the next generation of experts. The new generation is then responsible to verify the correctness of the received knowledge and develop it further. At the end, the development of test criteria by different test organizations should lead to very similar results. Otherwise, different test organizations would come to a different grading for the same test object, a highly undesirable situation.

The grading decision must be based on well defined evaluation criteria. Such criteria can only be applied on raw AE data, if certain prerequisites are fulfilled, e.g., the strict following of a written instruction how the test has to be performed, what equipment and accessories to be used, what information to be gathered before and during the test and how follow-up results of other NDT performed earlier on the test object might influence the grading.

With raw AE data from hundreds of tests, the experts "on principle" possess enough data to substantiate the correctness of their evaluation criteria with evidence.

Raw AE data are usually archived, but in many cases not in a sufficiently systematic manner to be used as an evidence. The verification of the evaluation criteria by analysing a large number of data files manually, file by file, would be a very tedious and expensive job, that calls for automation.

There are a lot of similar requests for an automated AE data analysis, for example, the optimization and verification of a pattern recognition classifier, or a setup for additional feature extraction from transient recorder files. So it is due time to offer software that can do such jobs in an automated and efficient way.

Three software items are needed for such a job:

1. A versatile data analysis program, Vallen VisualAE, that makes the requested results available for further data processing. Results could be, for example, the number of located events within a cluster of at least "X" members, with a distance corrected amplitude greater than "Y"dB_{AE}, or, the number of events, filtered by certain conditions, and classified to a certain kind of source mechanism, etc. etc.. Vallen VisualAE software will be steadily extended with new results for such automated analysis in a most flexible way.

2. A sequencer program, Vallen Multi-File Sequencer (**VAMUS**), for the automated sequential analysis of multiple data files.

3. A data base tool for raw AE data, Vallen Data Manager (**VADAM**), that manages raw AE data plus additional information needed per data file for a comfortable search and selection of AE data to be automatically analysed. Of course, other applications of AE, where a lot of data files are generated, would also benefit from using VADAM to easier manage the raw AE data plus test descriptions, reports, drawings, written instructions, procedures, variations in the setups, results, etc..

4. An EXCEL sheet where the automated results are transferred to and can be visualized or further processed according to the user's needs.

2. Principle Concept of VAMUS

An automated analysis of "F" measurement files, in order to get "R" results and "D" diagram files (BMP, JPG or PNG format) per measurement, could be realized by a sequencer program that performs the following steps:

Step	Action	Parameter
1	Clear FileCounter	
2	Increment FileCounter	
3	Get filename from parameter list	Filename(FileCounter)
4	Run Feature Extractor on that file	Yes/No, Generic setup
5	Run VisualAE on that file	Generic setup
6	Store "D" Diagram files (Bitmaps / ASCII-Files)	List of VAE diagrams
8	Extract "R" numeric results into an EXCEL sheet	List of VAE results
9	If FileCounter < "F" (number of files) goto step 2	
10	Finished	

3. Parameter Definition

VAMUS asks for the following parameters.

- Path and name of the generic VisualAE and Feature Extraction Setup for all files to be processed.
- List of the numeric results to be extracted
- List of the diagrams to be stored as bitmap (bitmap settings taken from VAE file) and / or in ASCII format
- Path where diagrams shall be stored (same name as data file, distinct extension)
- Name of the data range that shall be processed

Some data files may contain data ranges filled with pencil lead breaks, auto-calibration data, trial data, or other data that should or should not be processed by the automated analysis. Those data ranges are to be identified by names as described in next chapter. This means, additional information per data file are needed for the automated analysis. For this and other reasons, the automated data analysis needs to manage raw AE data with the help of a data base tool (VADAM).

For the automated analysis, an EXCEL sheet (path and name of the VAE setup) has to be prepared in column A with identifiers of the files to be processed. The control program goes through this EXCEL sheet, line by line, reads the identifier, processes the file, and stores the requested results in the columns B, C, D, .. next to the data identifier. The user could then use these automatically obtained result data for visualization by an EXCEL diagram or for any further calculation.

4. Data Base Tool VADAM

VADAM (Vallen Data Manager) offers powerful means for a search and an automated selection of data of certain criteria. The user can enter into the data base the following information per AE data file:

Data Identifier	a short name (single line string) of the measurement
Description	any string of any reasonable length describing the data. This string is presented in a multi line window. The data base tool would allow to search in this field and select automatically, for example, all data files containing a substring used as a search criterion, e.g. "concrete" or "tensile" or "corrosion", or whatever one searches for
Date	of measurement
Object	String identifying the test object, or a reference into a separate test object data base
Owner	String identifying the owner or operator of the test object
Location	String identifying the location of the test object
System Id	string that identifies the AE system that has acquired the data
Operator Id	the test engineer conducting the test
SupervisorID	the supervisor responsible for the test
Instruction	String that refers to the observed standard/ procedure / written instruction
Test Result	String defining the grading result and the sources found
Data01..Data10	10 user-definable values, e.g. test pressure in bar, capacity in m^3, etc., that can be used for the automated selection of tests. User can change the headers, e.g. "Data01" to any other term, e.g. "Test pressure in bar"
Range01..Range25	up to 25 data range definitions, whereby each range may define multiple from-to dataset numbers in the primary data file. The user can define the name for each of the 20 ranges out of a list (e.g. TestData, PLBs, AutoCal, PretestPLB, PosttestPLB, PretestACal, PostTestACal, BetweenACal, 1^{st}load, 2^{nd}load, 1^{st}hold, 2^{nd}hold, 1^{st}decrease, 2^{nd}decrease, 1^{st}increase, 2^{nd}increase, etc.) On default, the complete file is assigned to Range01 and the name TestData is assigned to Range01.

The following information are also stored in the data base per file, but managed exclusively by the data base tool:

Data link	path and name where the raw data are stored. The user can import the raw data plus other files belonging to the measurement, e.g. intermediate and final reports, notes made during the test, written instruction, relevant procedure, etc.. The data base tool copies the data on a self-decided path and name and allows a retrieval of the original files at any time.
Key	internal unique identification of each entry

Any field of the data base can be selected for a substring search. In the fields Data01 to Data10 one can search for a numeric range (e.g. all files with a test pressure between 150 and 200 bar).

Since the software is still under development, some changes in the specification are probable.

5**. Conclusion:**

The increase of the amount of raw AE data in possession of many testing organizations calls for a systematic data management and an automated multi-file analysis. This would help to substantiate the correctness of evaluation criteria with evidence based on taken measurements. It also would help to verify and optimize classifiers for pattern recognition and setups for additional feature extraction from transient recorder files (waveform data).

The reduced costs and increased storage capacities of hard disks makes the direct access for a multi-file analysis nowadays possible.

Additional information, such as identifiable data ranges on the test data, are to be observed for the automated multi-file analysis. This and other reasons call for managing the raw AE data by a data base tool.

A first version of a software for the mentioned purpose is under development and planned for presentation at EWGAE 2004:

The Vallen Multi File Sequencer (VAMUS) is to control the data analysis of multiple files.

The Vallen VisualAE will be extended with functions and results as needed and useful for a multi-file data analysis.

The Vallen Data Manager (VADAM), originally developed as a Vallen-internal document managing system, will be extended with functions useful for the managing of raw AE data and related information and documents, such as descriptions of the test itself, the test object, notes made during the test, written instructions, procedures, drawings of the test object, and more.

6. Acknowledgement