Workpackage [WP3]


Deliverable/Task Leader: [UNITN]
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ABSTRACT

The SERIES Work Package WP3 NA2 is relevant to the Networking Activity and aims at creating the conditions leading to the qualification - assessing their technical competence and in form of mutual accreditation - of Large Structural Testing Facilities specialized in earthquake engineering. The activities of WP3 NA2 were subdivided in four tasks; in these, task 3 - which is the object of this report - addressed the criteria for instrumentation and equipment management. Relevant information was gathered by diffusing a questionnaire in 33 European large testing facilities, industries and Accreditation or Standardization Organizations. The collected data were critically assessed and exploited to write this deliverables report. According to answers, most of laboratories apply some procedure for instrumentation and facilities management, but only slightly more than half declare the utilized procedure and less than 10% refer to standards. The existing accreditation norm, as ISO/IEC 17025:2005, can be obtained with reference to each different tests and are not relevant to the laboratory: therefore the cost for the implementation and maintenance of the required quality management system is important. Moreover, particularly research tests are not easy to be standardized, since they often involve numerical methods or instrumentation developed by Laboratories themselves. This considerations emphasize the actuality and importance of this subject.

Keywords

Certification: The formal procedure by which an accredited or authorized person or agency assesses and verifies (and attests in writing by issuing a certificate) the attributes, characteristics, quality, qualification, or status of individuals or organizations, goods or services, procedures or processes, or events or situations, in accordance with established requirements or standards.

Accreditation: The certification of competence in a specified subject or areas of expertise, and of the integrity of an agency, firm, group, or person, awarded by a duly recognized and respected accrediting organization.

Qualification: The process to demonstrate the ability to fulfill specified requirements (ISO 9000).

Standard: A technical specification approved by a recognized standardization body for repeated or continuous application, with which compliance is not compulsory (Directive 98/34/CE).
Facility/Facilities: The laboratory/laboratories dealing with the large-scale seismic testing and/or monitoring of structures.
ACKNOWLEDGMENTS

The research leading to these results has received funding from the European Community’s Seventh Framework Programme [FP7/2007-2013] under grant agreement n° 227887.
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1 Work Package 3 Overview

1.1 INTRODUCTION - RELATED AIMS OF THE SERIES PROJECT

SERIES project aims at bridging the two gaps of RTD in experimental earthquake engineering and structural dynamics:

(a) between Europe and the US or Japan, and
(b) between European countries with high seismicity but less advanced RTD infrastructures on one hand and some more technologically advanced but not so seismic Member States on the other.

It will do so by integrating the entire European RTD community in earthquake engineering via:

- A concerted program of Networking Activities, fostering a sustainable culture of cooperation among all research infrastructures and teams active in European earthquake engineering;
- A distributed database of test results, pooling data from the beneficiary research infrastructures and others, accessible and maintained by a virtual research community after the project’s end;
- Tele-presence and geographically distributed concurrent testing at the research infrastructures;
- Standards, protocols and criteria for qualification of RTD infrastructures in earthquake engineering;
- Enhancement of human resources by training new users and beneficiary technical/research personnel in courses on good practices in operation and use of research infrastructures;

The networking activities of the project will enhance the services provided by the research infrastructures, transcending their current extreme fragmentation, through the following:

- The creation of a very large virtual European research laboratory, through tele-presence and geographically distributed testing at the participating research infrastructures;
- Wide sharing of data and knowledge across the field of earthquake engineering and between academia, research and industry, through a web portal and distributed database, to be maintained and enhanced well beyond the end of the project;
• A better structure and integration at a European scale of the way similar research infrastructures operate, developing synergies and complementarities between them and fostering their joint development in terms of performance and access;

• Common European standards and protocols for similar research infrastructures and qualification criteria for European research infrastructures in earthquake engineering.

1.2 DESCRIPTION OF WP3 NA2

WP3 NA2 is the Networking Activity of the SERIES Project whose aim is to create the conditions leading to the qualification of Structural Testing Laboratories specializing in earthquake engineering and equipped for large scale testing.

For the qualification it was recognized that the combination of two main requirements on the laboratories is necessary: technical competence and quality assurance. The final objective of the accreditation is to guarantee the reliability of testing in each laboratory. In reliability implicit is repeatability, i.e., the principle that experimental activities repeated on the same specimen in the same laboratory lead to the same result (within, of course, certain tolerances and fixed conditions). The conclusions of the assessment of instrumentation management procedures in Tasks NA2.3 will most likely lead to a critical analysis of the requirements imposed by official standardization and accreditation organizations, National and European.

The activities in NA2 will address the assessment criteria for technical competence of the beneficiary laboratories – and of similar ones in future – and develop the basis for their accreditation, mutual or from an accrediting organization. Focus will be given on seismic experimentation through real-time (shake table), pseudo-dynamic (reaction wall) or even quasi-static testing and on-site testing and monitoring, activities which concerns all research infrastructures in this project.

The carried out activity directly involved most European Structural Research Infrastructures performing seismic experimentation and equipped for large scale testing; furthermore the networking involved the users of the research infrastructures (S/T community and Industry), which will ultimately draw the benefits from the qualification of laboratories for Products Certification.

The activities in Work Package 3 NA2 were defined under four tasks:

1. NA2.1: Evaluation and impact of qualification of experimental facilities in Europe
2. NA2.2: Assessment of testing procedures and standards requirements
3. NA2.3: Criteria for instrumentation and equipment management
4. NA2.4: Development and implementation of a common protocol for qualification

Task NA2.1: Evaluation and impact of qualification of experimental facilities in Europe

The task included a critical analysis of problems limiting the free circulation of the products of the European Industry: the qualification of structural laboratories should promote its solution. A
second task was the analysis of issues – of technical, quality or commercial relevance - which in fact constitute obstacles to the mutual accreditation.

Final Users (Industry) and Accreditation or Standardization Organizations were directly involved, through questionnaires and meetings.

The task ended by the performance of the following activities:

- to collect all the data from the questionnaires
- to draw the conclusions of the study of technical, quality and commercial relevance problems related to the accreditation of Large Testing Facilities Laboratories
- to draw a roadmap towards a common protocol for mutual accreditation.

**Task NA2.2: Assessment of testing procedures and standards requirements**

The focus of this task was on Shaking Table and Reaction Wall facilities: owing to differences in technical solutions and to the variety of testing procedures, fully harmonized approaches are particularly difficult to be achieved. The work was based on a comparative analysis and on the critical assessment of procedures and equipment followed by facilities. The compliance of the different procedures with the requirements of the applicable standards or reference recommendations were critically assessed. There was exchange of information among the laboratories, round visits of test operators to the co-operating facilities, especially on the occasion of important or benchmark tests. Data collected with the questionnaire were critically assessed and a deliverables report was printed.

The objectives of task 2 were the following:

- to collect data and information on the testing procedures used for seismic experimentation;
- to assess the collected information;
- to produce a concluding report of the task.

**Task NA2.3: Criteria for instrumentation and equipment management**

This task treated the issue of the management criteria of the Laboratory instrumentation and equipment management - testing equipment, measuring instrumentation, acquisition systems and processing tools - including the issues related to the calibration of instruments - periodicity and technical conditions - their maintenance, the estimation of measurement uncertainty, the practice used for applying measuring instrumentation on specimens, etc. Data collected with the questionnaire were critically assessed and a deliverables report was printed.

The objectives of task 3 were the following:
• to collect data and information on the laboratory use of instrumentation and its management for seismic experimentation;
• to assess the collected information;
• to produce a concluding report of the task.

Task NA2.4: Development and implementation of a common protocol for qualification

The starting point of this task was the International Workshop on “Role of research infrastructures in performance-based earthquake engineering”, organized by beneficiary IZIIS in Ohrid (Republic of Macedonia), in conjunction with the 14th European Conference in Earthquake Engineering in Sept. of 2010. A day of that workshop was dedicated to NA2, with the participation of the beneficiaries in NA2 and of representatives from Industry and European Accreditation or Standardization Organizations, specially invited to this event. The occasion was exploited for informing the audience about the goals and progress so far of NA2, disseminating the achieved results and receiving feedback from Industry and from the representatives of Accreditation or Standardization Organizations.

Using as baseline the outcomes of Tasks NA2.1 to NA2.3 and the conclusions of the discussion at the Workshop, the most important part of this NA2 was the development of a draft Common Protocol for the qualification of research infrastructures in earthquake engineering, in agreement among the beneficiary facilities. It gives in detail the technical rules and the quality assurance approach to be adopted as a condition for mutual accreditation of earthquake engineering laboratories. The protocol, to be implemented on a voluntary and pilot basis in the laboratories of selected Beneficiary research infrastructures, will be supplemented by the necessary technical guidance and recommendations, in the form of Technical Annexes.

Potential difficulties in the application of the draft protocol will be highlighted by its pilot implementation and the protocol will be revised into a final Common Protocol for the qualification of research infrastructures in earthquake engineering.

The task should produce the following documents:
• a draft Common Protocol for Qualification;
• the final version of the Common Protocol for Qualification.

1.3 GENERAL CRITERIA AND REFERENCES

1.3.1 References

The activities were conducted with reference to the documents listed at the end of the present report.
1.3.2 General criteria

The activities of WP3 are conducted making reference to docs. from [8] to [14]; the justification of this choice is following:

- As far as the two main requirements for the qualification of the laboratories, quality management system and technical competence, a sound experience is available in the application of international standards as docs. from [8] to [10]; this choice will allow to fulfill the requirements of the last task of NA2, when a contribution from European Accreditation or Standardization Organizations is expected to reach an agreement to issue a final Common Protocol for the qualification of research infrastructures in earthquake engineering;
- From a technical point of view the mutual accreditation is a tool to guarantee the reliability of testing laboratories: reliability is translated in practice into
  - Repeatability [15], the principle that experimental activities repeated on the same specimen in the same laboratory lead to the same results, and
  - Reproducibility [15], the principle that experimental activities repeated on the same specimen in different laboratories lead to the same results.

Repeatability and reproducibility can be easily achieved if common standard test procedures are used. Moreover a common language can be established on the basis of international standards which could help avoiding mismatches and misunderstandings.

1.3.3 Task NA2.3:

As other tasks of WP3, NA2.3 includes the following activities:

- Identification of European Large Testing Facilities with Shaking Tables and Reaction Walls operating in the seismic field;
- Preparation of a questionnaire to be circulated among the identified Large Testing Facilities in order to collect information about:
  - Procedures for testing management;
  - Check of the compliance of the procedures with the requirements of the applicable standards or reference recommendations for the performance of experimental seismic testing
  - Check of the compliance of the procedures with the requirements of the applicable standards or reference recommendations for the performance of data acquisition and processing, including frequency analysis, statistic and modal analysis;

As a specific task of NA2.3, the following activities were performed:

- Comparative analysis and critical assessment management procedures;
- Production of the report of the task
2 Collection of information

2.1 PREPARATION OF THE QUESTIONNAIRES

In order to save time and to optimize the compilation of the questionnaires by the contacted Institutions, it was decided to prepare only four questionnaires covering all the issues of task 1, 2 and 3. After collection of the filled questionnaires, data were processed by each task leader with reference to the specific parts dealing with the relevant task objectives.

2.2 EUROPEAN LARGE TESTING FACILITY QUESTIONNAIRE

The questions related to the instrumentation management were:

- **Qualification state: standards**
  - Does the Facility adopt Standards for the management of measuring equipment (measurement transducers, cables, signal conditioners and amplifiers, filters)?

- **Technical requirements: accommodation and environmental conditions**
  - Are the testing and calibration, lighting and environmental conditions appropriate for the correct performance of the tests?

- **Technical requirements: equipment**
  - Is the measurement and test equipment appropriate for the type of tests you are conducting?
  - Does the Facility ensure that all test equipment: complies with the test specification? is calibrated? allows for the correct performance of the test?
  - Is the deployed equipment uniquely identified as follows?
  - Name and description of the equipment and its software; Name of the manufacturer; model number and serial number; Initial check in with respect to the purchasing requirements; Date of receipt and date of start up; The current location, where appropriate
  - Is the maintenance of all the employed equipment specified as follows?
  - Manufacturer’s instructions; The maintenance plan and maintenance carried out to date; Frequency of maintenance; Log of damage, malfunction, modification or repair?
  - Is the calibration of all the employed equipment recorded as follows: Dates, Results, Copies of reports, Certificates of all calibrations, Due date of next calibration.

- **Maintenance**
  - Does the Facility have procedures for the maintenance of the test equipment?
• **Calibration**
  
  o Does the Facility have calibration procedures stating responsibilities and calibration time intervals?
  
  o Does the Facility perform intermediate controls between two calibration dates?

3 **Analysis of data**

3.1 **INTRODUCTION**

34 Large Testing Facility answered the questionnaire. There were 1 response from an international institution, 1 from Belgium and Germany, 2 from France and Romania, 3 from Greece and UK, 5 from Portugal, and 8 from Italy and Turkey.

3.2 **EUROPEAN LARGE TESTING FACILITIES LABORATORY RESPONSES**

Answers from large facilities to main questions of Section 2.2 are summarized hereafter:

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the Facility utilize defined procedures for instrumentation management?</td>
<td>72%</td>
<td>28%</td>
</tr>
<tr>
<td>Percentage of standard procedures</td>
<td>6%</td>
<td>94%</td>
</tr>
<tr>
<td>Does the Facility utilize defined procedures for equipment management?</td>
<td>66%</td>
<td>34%</td>
</tr>
<tr>
<td>Percentage of standard procedures</td>
<td>8%</td>
<td>92%</td>
</tr>
<tr>
<td>Does the Facility adopt Standards for the management of measuring equipment?</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>Are the testing and calibration, lighting and environmental conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Percentage</td>
<td>Score</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>appropriate for the correct performance of the tests?</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Is the measurement and test equipment appropriate for the type of tests you are conducting?</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Does the Facility ensure that all test equipment complies with the test specification?</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Does the Facility ensure that all test equipment is calibrated?</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>Does the Facility ensure that all test equipment allows for the correct performance of a test?</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Is the deployed equipment uniquely identified as name and description of the equipment and its software?</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Is the deployed equipment uniquely identified as name of the manufacturer, model number and serial number?</td>
<td>86%</td>
<td>14%</td>
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<tr>
<td>Is the deployed equipment uniquely identified as initial check in with respect to the purchasing requirements?</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>Is the deployed equipment uniquely identified as date of receipt and date of start up?</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Is the deployed equipment uniquely identified as current location, where appropriate?</td>
<td>90%</td>
<td>10%</td>
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<td>Is the maintenance of all the employed equipment specified as manufacturer’s instructions?</td>
<td>86%</td>
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<td>Is the maintenance of all the employed equipment specified as the maintenance plan and maintenance carried out to date?</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>Is the maintenance of all the employed equipment specified as frequency of maintenance?</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>Is the maintenance of all the employed equipment specified as log of damage, malfunction, modification or repair?</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>Question</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>Is the calibration of all the employed equipment recorded as dates?</td>
<td>86%</td>
<td></td>
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<tr>
<td>Is the calibration of all the employed equipment recorded as results?</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>Is the calibration of all the employed equipment recorded as copies of reports?</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>Is the calibration of all the employed equipment recorded as certificates of all calibrations?</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>Is the calibration of all the employed equipment recorded as due date of next calibration.</td>
<td>86%</td>
<td></td>
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### 3.3 SYNTHESIS OF RESULTS

Answers show the perception of large seismic testing laboratories managers to own adequate facilities, instrumentation and procedures for performing a correct testing activity. The calibration of the acquisition instrumentation is periodically checked and the relevant database is maintained and updated. Moreover, most of laboratories apply procedures for management of measuring instrumentation and equipment. A lower percentage possess procedures for assuring the properness of experimental tests: however, only slightly more than half of the laboratories declare their own utilized procedure and less than 10% refer to standard procedures.

Therefore a paradox in the answers exists, since on one side tests are performed by experienced scientists with a very high instruction level and there aren’t doubts about the reliability of results; on the other side, only few laboratories refer to written procedures to this aim, and a minimum number to standards. The qualification requires specified procedures for instrumentation and equipment management: these could be either international standards or internal procedures. The firsts should be fulfilled when specified by product standards, whilst it is opinion of the authors that internal, written procedures should be followed in research tests.

One major problem is related to the cost for the implementation and maintenance of the standard management quality system, both monetary and in term of personnel required for this aim. Some researchers believed that only laboratories performing qualification tests for private companies had the possibility to have the necessary funding, differently from purely research institutions.

As far as known by the authors, the cost of the Accreditation Body in Italy for a three days audit on ten test types is about 12,000,00 € and for a two days audit on three test types is about 4,000,00 €; the cost depends on the type and number of tests and consequently of inspectors. The costs for the implementation of the Quality Management Manual and the Managing Procedures...
depends on the availability of written procedures: if this is the case, it should be an easy task to prepare the procedures for an audit by a third party. Conversely, one year of work of one person should be sufficient to write the procedures required to obtain the certification of the management system according to ISO 9001; therefore, the cost in Italy can be quantified in 40.000,00 euro. All mentioned cost don’t include VAT.

With reference to standards, it should be noticed that particularly research tests are not easy to be standardized, since they often involve numerical methods (for RW) and sometimes equipments and instrumentation developed by Laboratories themselves. Conversely, several standards of qualification tests with shaking table are available for testing electrical equipment and some for other mechanical systems and components. However, it is opinion of the Authors that a common reference document or standard containing details on periodicity of instruments calibration, as an example, should be useful as a base for the qualification in order to identify the procedures to be developed and their contents. Hopefully, this document could be developed in NA2.4.

References

The activities were conducted with reference to the following documents:

1. COMMISSION OF THE EUROPEAN COMMUNITIES – SERIES: SEISMIC ENGINEERING RESEARCH INFRASTRUCTURES FOR EUROPEAN SYNERGIES - Grant Agreement Number 227887.

2. COMMISSION OF THE EUROPEAN COMMUNITIES – SERIES: SEISMIC ENGINEERING RESEARCH INFRASTRUCTURES FOR EUROPEAN SYNERGIES - Project Number 227887 - Grant Agreement Preparation Forms


5. Grant agreement No. 227887 for: Integrating Activity - Combination of Collaborative Project and Coordination and Support Action – SERIES - SEISMIC ENGINEERING RESEARCH INFRASTRUCTURES FOR EUROPEAN SYNERGIES - Annex III: SPECIFIC PROVISIONS FOR TRANSNATIONAL ACCESS ACTIVITIES.


11. WP3NA2-0004 – QUESTIONNAIRE FOR LARGE TESTING FACILITIES INSTITUTIONS.

12. WP3NA2-0005 – QUESTIONNAIRE FOR CERTIFICATION AND ACCREDITATION INSTITUTIONS.

13. WP3NA2-0006 – QUESTIONNAIRE FOR STANDARDIZATION INSTITUTIONS.

14. WP3NA2-0007 – QUESTIONNAIRE FOR INDUSTRY INSTITUTIONS.


17. WP3NA2-0002 – Minutes of the meeting in Iasi (Rumania).

18. WP3NA2-0009 – List of the European Institutions.


20. ISO 6070 - Auxiliary tables for vibration generators - Method of describing equipment characteristics

21. ISO 8626 - Servo-hydraulic test equipment for generating vibration - Method of describing characteristics

22. ISO 5344: Electrodynamic vibration generating systems - Performance characteristics


27. ISO 21289:2008: Mechanical vibration and shock -- Parameters to be specified for the acquisition of vibration data


34. ISO 5725-1:1994 - Accuracy (trueness and precision) of measurement methods and results - Part 1: General principles and definitions

35. ISO 5725-2:1994 - Accuracy (trueness and precision) of measurement methods and results - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method.


37. ISO 5725-4:1994 - Accuracy (trueness and precision) of measurement methods and results - Part 4: Basic methods for the determination of the trueness of a standard measurement method.


Annex A – Graphs of answers

Figure A.1: Does the Facility utilize defined procedures for instrumentation management? If so, please list the instrumentation management procedures.

Figure A.2: Does the Facility utilize defined procedures for equipment management? Please list the equipment management procedures.
Figure A.3: Does the Facility utilize defined procedures to which assure the performance of experimental tests? If so, please list the test procedures.

Figure A.4: Does the Facility ensure that all test equipment:
   a) complies with test specification?
   b) is calibrated?
   c) allows for the correct performance of a test?
Figure A.5: Is the deployed equipment uniquely identified as follows?
  a) Name and description of the equipment and its software
  b) Name of the manufacturer; model number and serial number
  c) Initial check in with respect to the purchasing requirements
  d) Date of receipt and date of start up
  e) The current location, where appropriate

Figure A.6: Is the maintenance of all the employed equipment specified as follows?
  a) Manufacturer’s instructions
  b) The maintenance plan and maintenance carried out to date
  c) Frequency of maintenance
  d) Log of damage, malfunction, modification or repair
Figure A.6: Is the calibration of all the employed equipment recorded as follows?
   a) Dates
   b) Results
   c) Copies of reports
   d) Certificates of all calibrations
   e) Due date of next calibration