A methodology for achieving effective market surveillance of power transformers – INTAS project

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***Abstract*—Market Surveillance Authorities (MSAs) and market actors face difficulties establishing and verifying compliance of large industrial products. The INTAS project is funded by the European Union Horizon 2020 Programme (EU H2020) to provide technical and cooperative support, as well as capacity building to MSAs targeting transformers which are subject to energy performance requirements under the Ecodesign Directive.**

In a first stage, the existing testing avenues, and explored test standards, procedures and methods already in place have been analyzed. Now, the project is defining an effective compliance framework for MSAs and manufacturers.

Specifically, INTAS aims to: Support EU MSAs deliver compliance; Support industry on their obligations under the Ecodesign Directive and delivering compliance that will be broadly accepted by MSAs; Foster a common EU approach to delivery and verification of compliance.

Focusing on the strengths and limitations of current industry practices, the final goal is to define recommendations on methodologies and required documentation.

***Index Terms*— Ecodesign, energy efficiency, formal verification, power transformers, market surveillance**

I. INTRODUCTION

The INTAS project, acronym for Industrial and Tertiary Product Testing and Application of Standards, funded by the EU's Horizon 2020 programme, started in March 2016 to address the need to support European Market Surveillance Authorities (MSAs) deliver compliance with Ecodesign requirements for large industrial products, specifically transformers and fans.

As a significant contribution to support the goals of the EU energy efficiency targets in 2020, the implementation of the Ecodesign Directive [1] alone should provide yearly savings of up to 600 TWh of electricity and 600 TWh of heat. To achieve these targets, the Ecodesign Directive has moved its focus also into very large products, including power transformers as covered by Ecodesign Regulation (EU) No. 548/2014 [2].

However, weak enforcement by national MSAs contributes to non-compliance, reducing the envisaged energy savings by an estimated 10% [3]. Effective market surveillance hence can help to reduce significantly these potential losses.

The need for the INTAS project arises from the difficulty that MSAs face in establishing and verifying compliance with Ecodesign requirements for large industrial products [4]-[6].

Specifically, INTAS objectives are:

- to support EU Member States' MSAs to deliver Ecodesign compliance for transformers and large fans;

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- to support industry to fully understand their obligations under the Ecodesign Directive and to deliver compliance in a manner that will be broadly accepted by MSAs;
- to foster a common European approach to the delivery and verification of compliance for these products.

The methodologies developed throughout the INTAS project will also lay the foundations and explore synergies for appropriate monitoring, verification and enforcement of other large industrial products.

The project will conclude in February 2019 and involves 16 European partners, among which 11 are national MSAs or cooperating organizations and the remainder are technical partners.

The energy performance of power transformers is currently being improved around the globe. In the EU alone, total losses in 2008 amounted to 93.4 TWh per year, equivalent to almost 12 percent of the continent's residential electricity consumption. Regulation No. 548/2014 covering these products has been in place since May 2014. The cost-effective improvement potential through more efficient design has been estimated at about 16.2 TWh per year in 2025, which corresponds to 3.7 Mt of CO_2 emissions, with a projected loss of 1.6-3.2 TWh (aggregate of the 10-20% expected loss through non-compliance).

It must be noted that within the INTAS project, both three-phase and single-phase medium and large power transformers (including auto-transformers) with a minimum power rating of 1 kVA as in the scope of the EU Regulation 548/2014 have been considered "large products" even if the current EN standard definition of large power transformers is more stringent.

II. ENGAGING NATIONAL AND EU STAKEHOLDERS

In order to fulfil the purpose of addressing the challenges faced by MSAs with regards to verification, it is important that current practices are examined, and input from all relevant actors gathered. Hence, the project has used different sources to organize, collect and address this information.

INTAS has adopted a national and EU-level approach where ten national project partners are acting as 'national focal points' for the different stakeholders (manufacturers, trade associations, retailers, importers, consumer and environmental organizations, and relevant national authorities within their own country) and one partner acts as the 'European focal point'. This national (and EU-level) focal point approach allows for a detailed, two-way communication in local languages, the consideration of regional issues and a wider dissemination of the project development and outcomes.

Furthermore, an Advisory Board to the project has been established which includes 12 experts representing all key stakeholders addressed by the INTAS project and who are kept informed of the project developments and provide feedback for instance, on the definition of the existing market surveillance framework and initial plans for testing activities.

Events and conferences also constitute another source of information on current situation and business and market surveillance practices.

III. CURRENT MARKET SURVEILLANCE PRACTICES AND CHALLENGES

A. Technical standards and legislative framework

For a long time, comprehensive international standards have been in place for laboratory testing but not in situ testing. Furthermore, standards clarifying the technical aspects of power transformer energy performance for use in contracts made between supplier and purchaser are available, including the aspects of the performance test arrangements, tolerances on data, conversion rules and documentation [7, 8].

With Ecodesign requirements in place, the performance of power transformers' energy performance is no longer just a private contractual matter between the supplier and the purchaser. The supplier must also establish technical documentation on their product's compliance before they are placed on the market and this documentation is subject to market surveillance checks. To support this, the European Commission has given a mandate to CENELEC to prepare a harmonized European standard [9].

Important background differences are evidenced in terms of adopted energy performance indexes and basic concepts/quantities assumed by the reference standards like:

- Rated power definition
- Reference temperature
- Rated frequency
- Rated maximum voltages of the equipment

With reference to the EU, some key aspects need further development in standardization and regulation:

- Exception formalization (how to manage possible exemptions)
- Which/how data shall be made public and how in the perspective of MSA
- Declared value definition confirmation
- Measurement uncertainty mandatory limits
- Very low power factor loss measurements
- Repaired transformer definition
- Dual voltage transformer definition
- Cooling consumption treatment

- Declaration of conformity standardized template

Initially, the consortium developed an internal report on the worldwide and EU current practices in market surveillance to collect information and build a firm understanding of the monitoring, verification and enforcement techniques used in major economies for power transformers, along with private schemes and alternative approaches. All collected methods were examined to identify the most interesting elements to be considered as suggestions and advice for the market surveillance procedure to be developed within the INTAS project for the EU Ecodesign Directive.

In all countries analyzed in the literature review the difficulties of the compliance verification for large industrial products are well known and there is also a clear lack of a unique and validated solution. Monitoring, verification and enforcement techniques are indeed applicable in all countries that were investigated, but no information is available on their actual application or on the results achieved. Some checks on Ecodesign information requirements take place in EU Member States, however, up to present none of the member states have been actively conducting verification testing for large power transformers.

At the national focal point meetings, stakeholders were asked about their main concerns regarding the ability of national authorities to perform market surveillance and/or testing power transformers. The preliminary analysis of the answers highlights the following issues:

- Workload/resources: lack of financial resources, lack of human resources, unavailability of products, unavailability of laboratories/measurement equipment, etc.;
- Specificities of the products: great diversity of customized large power transformers, to ensure that every product segments are verified, market surveillance methodology adapted to the different types of products, etc.;
- Capabilities: training is needed in order to improve MSAs/inspectors and personnel's knowledge;
- Lack of cooperation: within MSAs at different level, manufacturer-end user;
- Logistics: supply chain and project delivery dates, etc.;
- Need for clear and simplified procedures.

B. Commercial practices

In the current market situation, the energy performance assessment of power transformers is predominantly relying on the routine tests and data provided by the manufacturers themselves.

Hence importers/distributors and customers need to trust that they are receiving correct data documentation from their established manufacturers and the trustworthiness of their commercial relationship.

During the screening of existing testing avenues, INTAS identified only a handful of independent laboratories capable to perform tests on power transformers. Usually, independent laboratories are accredited by internationally recognized accreditation bodies (ILAC), which provide evidence of capability, experience, quality and good practices of the laboratories for the accredited tests and activities according the international standard ISO/EN 17025. The testing capacity range of independent laboratories is generally lower compared to major manufacturers' laboratories mainly due to economic constraints and limited market demand.

As part of normal commercial practice, manufacturers issue product nameplates, datasheets and technical catalogues for each product type, including relevant performance parameters like maximum level of losses.

Each power transformer unit is tested in the factory at the manufacturer's laboratory before delivery, and a test report is edited and attached to the transformer where the measured losses are explicitly compared to the guaranteed values in the contract.

Load and no-load tests are carried-out by power transformer manufacturers while cooling system energy performances are usually taken from the documentation.

The EU manufacturers' test facilities are at present not accredited by national accreditation bodies.

Usually for larger units and purely customized power transformers for electrical utility customers, the customer assists during the manufacturer tests as 'witness', or sends a commissioned expert on their behalf. Whereas in cases of more standardized medium voltage transformers, batch ordered, for distribution purposes, the customers seldom assist during the factory tests (e.g. only in case of major design changes from previously installed products).

IV. INTAS EXPLORATORY VERIFICATION OPTIONS

On the way towards defining the methodologies applicable for market surveillance of power transformers under INTAS, a number of options for compliance verification were explored:

- Documentation inspection of nameplates and technical documentation
- Testing transformers at 3rd party laboratory. Currently, 3rd party laboratory testing is not at all a standard option. Some larger utilities, buying high volumes of standardized medium size transformers, do some sampling for specific tests. Hence, they may also use

this sampling to perform energy performance verification in external independent 3rd party laboratories (usually at the beginning of the supplier qualification phase).

For MSAs, in the future verification of energy performance conformity of medium sized transformers however, if costs and logistics are reasonable, shipping and testing at an independent 3rd party laboratory might be a viable option.

- Testing transformers at manufacturer's premises or in-situ at the end user's premises, with the 3rd party laboratory measuring equipment
- Testing transformers at the manufacturer's premises with 3rd party laboratory measuring equipment, repeating the test with the manufacturer's measuring equipment
- "Witness" testing at manufacturer's premises in combination with manufacturer/utility/end user Factory Acceptance Testing (FAT) assessment. Some skepticism exists among MSAs about testing at manufacturers' premises for verification purposes. This relates for instance to the legal aspect of whether the product has been actually placed on the market in accordance with the Ecodesign legislation when it is still at the premises of the manufacturer during the test. Other issues concern the accuracy and transparency of the manufacturer's test procedures as well as if the product to be tested may have been optimized specifically for the verification test and do not represent the product actually placed on the market. It is evident that the situation of a market surveillance verification test differs from the commercial witness/acceptance testing in the sense that there may not be a mutual interest in the result of the test. However, in commercial contracts including acceptance/witness testing many of the practical issues are typically described and solved and with reference to available standards and guidelines.

  In case of very large power transformers, witness testing may be the only verification option and INTAS is investigating these procedures acceptable for both MSAs and manufacturers. This may include, but is not limited to, a kind of contract template/checklist with similar content as in commercial contracts that includes acceptance/witness testing. INTAS participated in a number of witness tests in order to adjust the methodologies. The outcome will be the development of guidelines on the use of the methodology.

Overall 42 units were investigated: 39 transformers were tested either by 3rd party laboratory, at manufacturers' premises or in-situ, or within a witness test; and 33 documentation inspections were accomplished.

Test exercises were performed in five EU member states. The size of the units ranged from medium power transformer (160 kVA / 20 kV) up to large power transformer (40 MVA / 72.5 kV).

For transformers all options have been verified in general as applicable, reliable and cost-effective, depending on the product size. The exception is in-situ testing, which is the most disruptive and costly testing method and should be considered a last-resort verification method. Related to the document inspection the issue of different definitions between "rated", "declared", and "guaranteed values" need to be cautiously distinguished.

V. OUTLOOK

A. Randomly visiting manufacturers' premises

Another option to be explored in INTAS and for future market surveillance procedures could be to have MSAs randomly visiting manufacturers' premises with or without previous announcement:

- If by coincidence, there is a "witness test" scheduled that day, the MSA would witness this test.
- If no witness tests are scheduled, MSA could do a random documentation inspection of available units.

In the latter, the MSA could also check the capability of the manufacturer/importer to fulfill Art. 8(2) of the Ecodesign Directive 2009/125/EC (e.g. the manufacturer is using either the internal design control set out in Annex IV or the management system set out in Annex V for the conformity assessment of its products).

B. Screening methodologies

As the costs and challenges of conducting verification testing for power transformers are considerable, there is an obvious interest in the application of risk screening processes within market surveillance processes to ensure the maximum market surveillance benefit is achieved at least cost. MSAs already have experience with non-conformity risk screening from the product safety but also the environmental and energy performance conformity domains, however, the experience is yet limited and thus, its application for large products is far from being standard practice. Contrary to what is the case with the mass product market, the business-to-business (B2B) procurement, manufacturing and placing on the market process' specific nature presents an additional challenge to even initiate market surveillance due to the fact that MSAs are not always aware of whether a product has been placed on the market (especially if no customs borders have been crossed).

Within the context that MSAs face to conduct market surveillance of power transformers there is the potential applicability of a variety of screening methodologies including:

- Market characterization screening to establish product types and their suppliers at industry or commercial trade fairs and similar events or fora
- Screening via the assessment of the quality of technical documentation and its internal consistency, availability of supporting evidence and implied understanding of the requirements
- Screening based on the established quality and/or independence of test reports (e.g. whether laboratories meet ISO 17025 requirements, are accredited, are 3rd party etc.)
- Screening based on the presence of other evidence supporting the veracity of the declared performance results e.g. witness testing, design simulation results, Quality Assurance (QA) and Environmental Management Systems (EMS) in place, etc.
- Screening in cooperation with other market surveillance authorities doing inspection for other regulations
- Screening in cooperation with customs authorities as well as voluntary certification scheme auditors
- Screening for:
  - Nameplate information
  - Plausibility check of design

The evidence being compiled aims to establish how the presence or absence of information derived through the above processes might create a hierarchy of risks that could guide a decision regarding whether or not to submit a product to full verification testing.

VI. CONCLUSIONS

Starting from the status-quo of virtually non-existing market surveillance for large transformers in the EU member states until now, INTAS is looking into existing standards, commercial practices and viable avenues and will develop methodologies to be used by MSAs in the future. So far, these can be based on theoretical assessments as well as practical exercises, including documentation inspection, testing of transformers by independent 3rd party laboratories, assisting at "witness" factory tests at manufacturers' laboratories or in-situ testing.

The INTAS project is in the process of conducting essential work to help enable effective compliance and market surveillance assessment of power transformers. The outcome of the above described verification and testing scenarios will lead to identify not only what is realistically possible to test based on size, performance, location, but what is the most cost-effective and reliable method to choose to determine the performance compliance based on either testing or other technical/documental approaches.

Interaction and engagement with the project from all relevant parties is strongly encouraged and welcome to help ensure the findings are as useful and viable as possible. Public documents will be made available on the INTAS webpage [10].

Several actions are being undertaken to support the project's technical activities: these include assisting MSA capacity building and networking, facilitation of information exchange, establishing dialogues with commercial actors and agencies, and the dissemination of findings. The process will culminate with the publication of an INTAS methodologies document, due in the second half of 2018.

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