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Executive Summary

This deliverable is an update to D2.3, which discussed the possible standards and regulations that could be relevant for the Hydroptics platform. Many of the identified regulations are intended to guarantee a safe operation of the device, meaning that neither other devices are affected nor persons get injured. The taken measures to ensure safe operation of the Hydroptics platforms will be presented as well as the findings to improve the alpha version.

The second topic of this deliverable discusses the possibilities to convert the implemented lab methods into an international standard. Here, the options, requirements and recommendations are presented and the updated situation is explained.

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1. Introduction

This report is an update of the deliverable D2.3 and origins from task T2.3. Here, the regulations and standards that are relevant for the Hydroptics project are identified and evaluated.

In the first section of this deliverable, we give an update on the legal requirements, that apply to the assembled alpha and beta version of Hydroptics platform. The focus is on the relevant European directives, that are implemented in the local laws of the individual countries. We describe why the particular directives apply for the Hydroptics platform and which measures will be taken to comply with them.

Then, the current status regarding the certification of the individual measurement methods is discussed. The identified options are presented and, based on the observations and the development progress, we will give a recommendation for standardization route.

2. Directives and Regulations

Before a product or service can be introduced on the market, the person or company has to ensure that it fulfills the local laws and regulations. To simplify this process, the European Union releases directives that have to be implemented in the local laws and harmonizes the legal requirements. Subsequently, the administrative tasks to check for the legal requirements is significantly reduced and simplifies the introduction of new services and products.

As it is one aim of Hydroptics to increase the TRL level from laboratory setups (TRL 3-4) towards sellable products (aim: TRL 6-7), it is of utmost importance to consider the applicable regulations and laws as soon as possible. Identifying the various requirements at an early stage of the project helps to avoid potential issues that could require major revisions and can reduce the time to bring a new product to the market.

During the planning and assembly of the alpha version of the Hydroptics platform, a series of directives that are of relevance for this project have been identified. They shall be discussed in further detail and examples for their applicability will be presented as well.

Directive 2014/35/EU – Low Voltage Directive (LVD)

This directive covers electrical equipment designed for use with a voltage between 75 and 1500 V direct current or 50 and 1000 V alternating current. It should be pointed out, that this limit addresses only the supply voltages and not the voltages within the device. Moreover, the directive does not cover individual components and evaluation kits destined for professionals at research and development facilities are excluded as well.

The complexity of the Hydroptics platform requires an input voltage of 230 V AC and an expected power consumption of approx. 1.5 kW. With the alpha version of the Hydroptics platform being tested only under lab conditions and being operated by experts, only the beta version must fulfill this directive. Good engineering practice of the experts developing and assembling the individual modules minimizes any potential risks and ensures safe operation of the Hydroptics platforms in compliance with this directive.

Directive 2014/30/EU – Electromagnetic Compatibility (EMC)

The term “electromagnetic compatibility” means, according the European Commission, the ability to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment. Possible sources of these disturbances can be incorrect installation of electrical motors, wires that can act as antennas or insufficient shielding.

Within Hydroptics, possible sources of electromagnetic radiation are the motors (especially brushed ones) used for the liquid handling and insufficiently shielded wires. To minimize the risk of influencing other equipment, adequate shielding, good engineering practice and high-quality power supplies will be used. Moreover, it should be pointed out that like in the Low Voltage Directive, evaluation kits (prototype) in research facilities are excluded. Therefore, this directive is only mandatory for the beta version of the Hydroptics platform.

Directive 2014/42/EU – Machinery Directive

The topics of this directive are the requirements that are necessary to bring a new machine/device to the market, whereas the term “machine” stands for an assembly of components that are joined together for a specific application. It applies to any device fitted with a drive system driven by other than human or animal effort. It discusses the minimum saftey measures and its documentation. It also includes the consideration of ergonomical aspects, a detailed risk assessment of the machine, risks caused by various hazards, and requirements for servicing, inspections and cleaning thereof. Again, devices for short term research work in laboratories are excluded thereof.

Both, the alpha and the beta version of the Hydroptics platform are equipped with moveable parts, especially driven by electrical motors. They drive, for example, cooling fans, peristaltic pumps, the mixer for the liquid/liquid extraction or the centrifugal separator. Measures to guarantee a safe operation are mechanical protection around the moving parts by installing a suited cover, and against unauthorized personnal by locking the door of the housing.

Ergonomical issues are addressed within Hydroptics as well: the user can interact with the software of the measurement device either by using a remote connection from the office, or with a bright and easy-to-use touch-screen. This touch screen is installed in a height of approx. 170 cm, which is at eye level and therefore ergonomical. Another aspect is transportability. To move the sensor platform to the intended measurement site, it is equipped with wheels (two wheels of each housing have brakes). Related to that, the overall dimensions (height, width and weight) have been selected that it can be moved by only two persons.

Directive 2014/34/EU – ATEX Directive (Explosive Protection)

This directive harmonises the laws relating to equipment and protective systems that are intended for use in potentially explosive atmospheres. Aside defining the obligations of manufacturers, the definition of notification bodies and the declaration of conformity, the directive lists safety requirements and how explosions can be prevented. These are, among others, reducing the risk of ignition by avoiding electrostatic discharge, prevent heating of mechanical parts, selection of materials and good engineering practice for safe design and construction.

The alpha version is equipped with brushed motors, that can cause sparks during their operation. With the beta version of the Hydroptics platform being installed in an industrial environment that is classified as ATEX Zone 2 - Group IIA/B, these motors will be replaced with brushless ones. Subsequently, the risk of sparks that could ignite an explosive atmosphere is minimized. Moreover, temperature sensors will be installed at different locations in the housing to prevent over-heating.

Directive 2014/32/EU – Measuring Instruments Directive (MID)

Measurement devices in the European Union are regulated by this directive. It lists the obligations of manufacturers, the importers and distributors who sell/trade such devices. Products that fulfill the requirements are to be marked with the capital letter “M” and the year of its affixing, surrounded by a rectangle (aside the CE marking).

The requirements defined by this directive apply for water meters, thermal energy meters, automatic weighing instruments and others. The device type “particle counter” or “oil meter” are not listed and does therefore not apply for the Hydroptics platform. However, several recommendations could be implemented. The device

documentation will include detailed documentation of the measurement range, the rated operation conditions, maintenance, repairs and the compatility with other interfaces.

Directive 2014/68/EU – Pressure Equipment Directive (PED)

The Pressure Equipment Directive sets the standards for the design and fabrication of pressure equipment. These are, for example, steam boilers, pressure vessels, piping and safety valves. It should be pointed out that their volume is generally over one litre and their maximum pressure is more than 0.5 bar. Other topics are essential safety requirements, conformity assessment procedures and the declaration of conformity.

After reviewing the components installed in the Hydroptics platform, none of the parts will build up a pressure >0.5 bar under correct operation. Therefore, this directive will not apply for the assembled prototypes.

Directive 2011/65/EU – Restriction of the use of certain hazardous substances (RoHS)

Hazardous substances in electronic products are nowadays a major issue. Considering the high complexity of electronic devices, it is a concern to limit the use of toxic substances that have been common in the industry. To address this topic in the European Union, this directive restricts the use thereof to protect the human health and the envrionment. In general, the use of lead, mercury, cadmium and hexavalent chromium (and some other substances) shall be avoided, but exceptions are listed as well. Like in other directives, equipment specifically designed for research and development are also excluded.

Relying on commercially available components and electronics modules makes it easy to comply with this directive. Already the alpha version is almost free of hazardous substances. Potential components, like mercury-cadmium-lead based infrared detectors, are excluded from the directive and hand-made circuit boards in combination with leaded solder are accepted due to the research characteristics. However, for a later commercialization of the Hydroptics platform, it is strongly recommended to replace the hand-made circuit boards with industrial printed circuit boards and to comply with this directive.

3. Standardization

In contrast to directives, that are converted into local laws, standards are voluntary guidelines that provide technical specifications for products, processes or services. They are often initiated by companies who see the need that a specific product or process has to be described in more detail to achieve its objective/intention. Other interested parties, such as regulators and consumers can participate as well and help to improve the quality of a standard.

Depending on the topic and the regional importance of a standard, different standardization bodies are available. These are, in particular, national bodies (e.g. DIN, ANSI), regional bodies (CEN, CENELEC, ETSI, …) or international bodies (for example: ISO, ASTM).

Since the deliverable D2.3, we have identified three different possibilities to implement the topic standardization within Hydroptics. The potential routes and the currently recommended approach are the topic of the following sub-sections:

3.1. Option A: Comply with existing standards

As the topic of measuring Oil-in-Water is not new, the industry has standardized a number of measurement methods over the time. They differ in the achievable precision, the sample preparation steps, the instrumental

requirements and the expected measurement time to get a result. A short overview on the most important standards that relate to the project Hydroptics are listed in Table 1.

Standard	Measurement method	Precision	Time effort	Comments
EPA 1664	Gravimetric	-	--	Extraction, evaporation of solvent
ISO 9377-2	Gas Chromatography	++	-	
ISO 16703	Gas Chromatography	++	-	
DIN 38409	Infrared (FTIR)	+	+	Requires the use of CFC (1,1,2-Trichlortrifluorethane)
ASTM D7678	Infrared (Laser)	++	+	CFC-free (Cyclohexane)
ASTM D8193	IR (Filter)	-	+	CFC-free (Cyclohexane)

Table 1: Selection of standards, relevant for Oil-in-Water measurements.

Similar, standards that define measuring the Total Suspended Solids have been identified as well and they are listed in Table 2. They often rely on filtration and subsequent weighing of the solids. Optical methods are available as well, however, due to the measurement technique, it is difficult to distinguish particles from oil droplets, leading to unprecise results.

Standard	Measurement method	Precision	Time effort	Sample preparation
ASTM D5907	Gravimetric	+	--	Filtration, drying of the sample
EPA 160	Gravimetric	+	--	Filtration, drying of the sample
Standard Method 2540D	Gravimetric	+	--	Filtration, drying of the sample
ASTM D3977	Gravimetric	+	--	Evaporation, filtration
ASTM D1889	Turbidity	-	++	Optical method

Table 2: Selection of standards, applicable for particles suspended in water.

With the coarse overview on standards that relate to the Hydroptics project, the first option is to comply with an existing standard. Although this seems to be a simple task and should be doable, this is not the case. It is not sufficient to implement a standardized measurement method in a working device – it is mandatory to fully comply with it. This includes that the whole sample preparation, device qualification process and the subsequent data evaluation and, if available, also the statistics must be fulfilled as described in the standard.

For the Oil-in-Water measurements, for example, the developed IR absorption based Dual-DFB-QCL setup could fulfill the technical requirements as standardized in the ASTM D7678. The sample preparation and taking the sample, however, is defined in this document as well. It requests the operator to take the sample manually, to

extract the oil with cyclohexane for a certain amount of time or to measure quality control samples from in defined intervals.

In Hydroptics, however, the sample preparation is fully automatized. Already the alpha version is equipped with an automatized batch-wise extraction step. Therefore, it is not possible to fulfill the manual sampling of the waste/process water. Neither the specified samples volumes, the required materials, nor the mixing times are fulfilled. Subsequently, it is inherently not possible to comply with the ASTM D7678 standard.

Similar, the newly developed Hyperspectral Imaging setup is experimental. Like for the Infrared based measurement, no standard has been found that could be fulfilled with the current setup.

The consequence of not being able to fully comply with an existing standard is that option “A” is no suitable route for the standardization of the Hydroptics platform.

3.2. Option B: Initiate a CEN/CENELEC Workshop Agreement

The second option to standardize the methods of Hydroptics is to initiate a CEN/CENELEC Workshop Agreement (CWA). This standardization route is strongly driven by the outcomes of Horizon 2020 and Horizon Europe projects, and relies on a strong interest of the industry regarding research and technological innovation. For innovative technologies and products, it is sometimes more important to have an early standard although the method is not yet fully established. It circumvents the situation where established companies try to prevent a new standard that could interfere with their already established ones.

The way to file a CWA is, in short, as follows (further details can be found in D2.3 and the CEN-CENELEC Guide 29):

- Submission of proposal form
- Draft of project plan
- Announcement on the CEN/CENELEC website
- Launching the Workshop
- Commenting phase
- Approval and Availability
- If possible/requested: adoption as European standard

With the progress of the ongoing developments, the updated list of potential technologies is as follows:

- Online oil in water extraction using cyclohexane and analysis with a Dual Frequency Comb Spectrometer
- Online extraction and separation using a mixing reactor and a centrifugal separator
- Enhanced absorption measurements based on Mach-Zehnder Interferometry
- Advanced particle identification and characterization using a Hyperspectral Imaging System (HIS)
- Data analytics based on machine learning for monitoring and predicting critical process parameters

The extended testing phase of the individual technologies has just started (Task 7.4, M24) and the field tests will begin in M35. Therefore, the presented list might change because of unexpected technical challenges. The CWA is a suitable standardization route and will be taken into further consideration.

While option A and B has already been discussed in deliverable D2.3, a third option has been identified:

3.3. Option C: No standardization during the project

The third option regarding standardization is to delay the process and to perform this task after the Hydroptics project. Although this could be seen as a drastic step, a standardization afterwards has several advantages too. The possible strategy could be as follows:

The time until the end of the project will be used to advertise the project in the industry. Thereby, awareness for online Oil-in-Water measurements will be created. This step includes different tasks, like presenting the results of the field tests at scientific conferences, promoting the installed technology at trade shows and advertising the need for online Oil-in-Water measurements at technical workshops.

Representatives of other oil producing companies and refineries will understand the importance of the installed technology and raise the question whether the technology is already standardized or not. Asking for a standard is already the perfect feedback because of two reasons: First, they are interested in continuously monitored water quality and therefore potential project partners for further testing. Secondly, they are maybe familiar with the standardization processes and, as they are experts in their fields, and they could have valuable contacts to other companies who face similar challenges. They could help with their knowledge and to create a consortium/work group that will push the technology and method development of online Oil-in-Water measurements even further.

Raising the necessary awareness and creating the demand for a standard is time consuming and will take longer than 12 months. With the identified importance of the technology, it will be possible to assign a consortium that will take the route for standardization. As the development of its standard is now being driven by the industry and not solely by the experts of the measurement device, the chances for acceptance of setting up a standard will be significantly higher.

An example for a successful product without having a standard is the Oil-in-Water analyzer “InfraCal 2 ATR-SP” from Spectro Scientific. This analyzer is based on Attenuated Total Reflection (ATR) technology and measures, after extraction using n-Hexane, the oil content. Although its measurement technique is not yet standardized, the robust and easy-to-use device is a successful product and installed in many labs.

3.4. Current and long-term strategy after the project Hydroptics

With the current status of assembling the alpha version of the Hydroptics platform, it is difficult to predict the outcome that is necessary for standardization. A successful standardization is only possible, if there is a clear demand of the participating parties. These can be companies from the industry itself, customers, who care about the quality of a product or a service, or even public bodies. Since the Hydroptics platform has not yet been tested in the field, only the developers of the platform show a clear interest on standardization. This, however, is a weak starting point considering the powerful committee members (representatives from the industry).

The planned evaluation of the Hydroptics platform in the field will change this situation, as the successful dissemination and communication will lead to a demand for its standardization. As soon as the industry is convinced about the benefits of the Hydroptics platform, they will support this task and promote either a CEN/CENELEC workgroup or join an ASTM work group.

Conclusions

In this deliverable we have reviewed the current implementation of the directives, that were identified in D2.3. Several of them have clear exceptions for prototypes and devices that are operated in dedicated lab environments. Subsequently, only a few are to be fulfilled with the alpha version. With the beta version being tested in the field, all of them shall be implemented to indicate the significant increase of the TRL level. Fulfilling the required directives and local laws already at an early stage of the project will increase the acceptance of the novel measurement setup by the industry.

In the second part of this deliverable, three options regarding standardization have been reviewed. Due to the current status of the project, it is difficult to predict the chances of standardization. This depends strongly on the demand from the industry, whether they agree that it is necessary to standardize our developed methods at all. Again, it should be pointed out that a successful product does not require/fulfill a standard at all (although it can be a powerful asset).

Appendix

List of Abbreviations

CEN	Commite Europeen de Normalisation
CENELEC	Comite Europeen de Normalisation Electrotechnique
CWA	CEN/CENELEC Workshop Agreement
ATR	Attenuated Total Reflection
CA	Consortium Agreement
ASTM	American Society for Testing and Materials
ISO	International Organization for Standardization
TRL	Technology Readiness Level