Full Material Declaration

A case study on the readiness for declaring Full Material Declaration of chemical substances in components, used in finished products

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Abstract

The production and usage of chemicals has grown exponentially over the past 50 years. Although the knowledge of hazards and risks associated with chemicals towards humans and the environment has increased, we know frightenedly little about how dangerous these might become when part of finished products. Companies now need to be more concerned about which chemicals exist in their products. For the company investigated in the present study, Alfa Laval, the information is needed to be able to meet potential future legislations, and to move towards a circular economy. This study investigates the readiness of suppliers to provide Full Material Declaration (FMD) for components used in one of the company's gasketed plate heat exchangers (GPHE). The study also uses an explorative literature review that serves as a mean to increase the understanding of the complexity of the topic at stake. The FMD investigation shows that the company investigated in this case study has knowledge about 93,2% of all chemicals in one of their most important products. The case study suggests that the most pressing challenges/barriers the suppliers for this product experience when being asked to provide FMD, are related to intellectual property, trade secrets and difficulties in information flow in the supply chain. To furthermore understand what challenges/barriers suppliers experience when asked to declare chemicals, a questionnaire was sent out to 48 of the company's suppliers. The questionnaire consisted of three quantifiable questions that could be answered with yes or no, and five qualitative questions, where the respondents were asked to answer the questions in his/her own words. In total, 15 suppliers answered the questionnaire. Some of the challenges/barriers are difficulties in information flow, administration work, sharing information which can be considered intellectual property, the complexity of materials, and if they have a large selection of traded articles. The study confirms the difficulties for companies and their suppliers in mapping chemical substances in products and components. The lack of clear and dispersed methods, systems, and complexity in the information chain, make it difficult to achieve the transparency needed to collect data, and the ability to share data with customers.

Populärvetenskaplig sammanfattning

Utmaning för industrin att kartlägga vilka kemikalier deras produkter innehåller

De flesta av oss associerar nog kemikalier med något negativt, men sanningen är att kemikalier utgör en förutsättning för mycket av den välfärd som vi ser idag. Tvärtemot vad man kan tro, så är det inte bara i produkter som plast, färg, lösningsmedel, med mera som dessa förekommer, utan även i produkter som räddar liv, till exempel i utrustning inom sjukvården och för vattenrening. Därför är de mellan 40 000 och 60 000 kemikalier som cirkulerar på den globala marknaden en viktig del i vardagen för miljontals människor. Samtidigt finns det ett okänt antal av dessa kemikalier som utgör potentiella hot mot natur och människor. Den ökade användning av kemikalier har resulterat i fler och hårdare lagkrav som tillverkningsindustrin måste följa. Men för att kunna möta dessa krav behöver industrin själva ha kunskap och kontroll över vilka kemikalier deras produkter innehåller.

För tillverkningsindustrin kan det vara en stor utmaning att få en hundraprocentig överblick över det kemiska innehållet i ingående komponenter. Detta gäller även Alfa Laval, ett svenskt företag med global försäljning och verksamhet och med höga ambitioner för sitt hållbarhetsarbete. De ville undersöka hur stor procentandel de kunde få kunskap om genom att dels titta på den information de själva redan har (i form av materialstandarder), dels genom att undersöka sina leverantörers möjlighet att tillhandahålla en fullständig materialdeklaration, kort sagt vilka kemiska substanser komponenterna de levererar till företaget i fråga innehåller. Den produkt man valde att undersöka är en av företagets bästsäljande, en Gasketed Heat Exchanger (värmeväxlare) som finns i olika modeller. Studien kartlade en enhet som kallas T15.

Genom att lägga ihop informationen från materialstandarder med redovisningen från T15-modellens fullständiga materialdeklaration från fem underleverantörer, har företaget i fråga nu kunskap om hela 93,2% av produktens totala kemiska sammansättning. Metoden kan användas för alla produkter som har materialstandarder kopplade till komponenter. Eftersom T15 är en standardprodukt och de andra värmeväxlarna i samma produktfamilj liknar varandra, har man redan

kommit en bra bit på väg i kartläggningen av alla produkter i värmeväxlarsortimentet.

För att få en ökad förståelse för vilka utmaningar underleverantörer har när de skall redovisa en fullständig materialdeklaration, kontaktades ytterligare 48 slumpvis valda leverantörer. Av de 15 svaren framgår, att även om de allra flesta underleverantörer tycker det är viktigt att bidra till kartläggning av kemikalier, finns det olika orsaker till att de inte kan tillhandahålla en fullständig materialdeklaration. Det framkom bland annat att man är rädd att information som kan anses vara affärshemligheter och eller intellektuell egendom, skulle kunna läcka ut. Vissa har också ett mycket stort antal komponenter som de i sin tur köper in, andra anger att informationen både är svår att samla in och att det kräver stora administrativa resurser. De angivna utmaningarna stämmer också överens med vad studien funnit i modern litteratur på området.

1. Introduction

1.1 Chemical substances in finished products

The production and usage of chemicals has grown exponentially over the past 50 years (R. Van Der Vegt, 2021). The chemical industry has become an important key sector for our everyday modern life activities. Today, there is not a single economic sector where chemicals are not considered to play an important role, and there are few to no manufacturing industries which can operate without it. We use manufactured chemicals in production of products for many different purposes and needs, reaching from healthcare and hygiene, paints and dyes, water treatment chemicals, fertilisers, to insecticides and pesticides for agriculture purposes. The list is almost endless (Golwalkar, 2016; R. Van Der Vegt, 2021; Cefic, 2021). Most modern-day products consist of hundreds of different chemicals (UNEP, 2019). Therefore, the contribution of chemical production is an important mean of subsistence for millions of people around the world. In other words, the materials which are extracted from the environment and produced by humans to produce chemicals, helps to contribute to an increased national welfare and global economics, which in turn yields to a richer and more comfortable living standard (Kemikalieinspektionen, 2017; UNEP, 2014; UNEP, 2019). Although people often

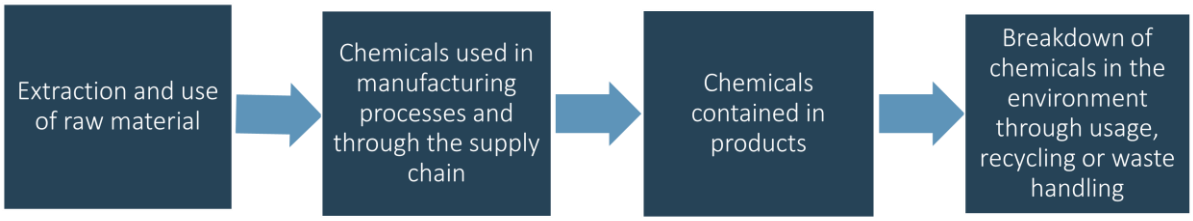

Figure 1. Figure inspired by Rossi 2014 and altered by the author, describing the general chemical lifecycle in products produced (Rossi, 2014).

associate chemicals as something negative, the quality of human life which we have gotten accustomed to today would be impossible without products made from or using chemical substances. For example, without chemicals, our society would not

have access to different variations of plastics, antibiotics, cleaning products, modern fabrics, and so on. However, we need to balance the potential risks, which might be significantly destructive towards our society and environment, against the benefits generated by chemicals (Royal Society of Chemistry, 2014).

Not all known chemicals used in production of goods and products are considered dangerous, but some chemicals have hazardous properties which can cause considerable adverse effects towards humans and the environment (Kemikalieinspektionen, 2017; R. Van Der Vegt, 2021). The knowledge of hazards and risks associated with chemicals towards human health and the environment has grown substantially over the past 40 years. However, there are still far too many chemicals circulating the global market which we know frightenedly little about, and the knowledge of how dangerous or how environmentally destructive these might be is still unknown (Johnson, Jin, Nakada and Sumpter, 2020; Scruggs, 2013). The vast number of chemical substances circulating the market thereby results in a knowledge gap between what chemicals are being used and how environmentally destructive they might become when being part of finished products (Johnson, Jin, Nakada and Sumpter, 2020). To put some numbers into perspective, the total number of industrial chemicals in use globally is estimated to be between 40,000 to 60,000, where 6 000 are estimated to account for more than 99 percent of the total volumed used (UNEP, 2019).

Although the total abundance of data which contributes to knowledge surrounding chemicals generated over the years has increased, there are still many data gaps and unknowns remaining. Knowledge about the volumes and hazardous of chemicals which are or will be introduced to the market are lacking in many regions and countries. The biggest knowledge gaps are estimated to include those chemicals which are produced in smaller quantities/volumes. Overall, complete data sets, surrounding sizeable number of chemicals are missing. This results in a limited understanding of the potential hazards concerning outdoor and indoor releases of chemical substances, during both production processes and from the finished products themselves, concentrations of hazardous chemicals in the environment, exposures, and advert impacts on health. Another contributing factor towards the increasing knowledge gap is the discrepancy remaining in the data collection and its availability over time and across countries, resulting in challenges concerning trends, baselines, and emerging priorities and issues (UNEP, 2019).

According to Van Der Vegt 2021, despite improvements and further refinements in international chemical management, policy and assessment, international and national governments still have a long way to go concerning the existing regulatory methods and frameworks, as these are not fully covering all hazardous chemicals. However, even when adequate information does exist, actors might frame the risk of hazardous chemicals differently due to splitting values, interests, and opinions (R. Van Der Vegt, 2021).

The essential backbone to understanding the knowledge gap concerning what chemical substances are being used when manufacturing products might be difficult to determine. According to Caroline E. Scruggs and Harry J. Van Buren 2014 and UNEP, 2019, companies sometimes have difficulties to determine exactly what types of chemicals and/or substances are being used in their own supply chain to create and produce a specific product, resulting in an incomplete understanding of what risks these chemicals might bring to humans and the environment when being part of the product itself (Scruggs and Van Buren, 2014). For larger companies these difficulties can, to some extent, be explained by the fact that the supply chains in many cases are extensive and vertically integrated, complex, and non-transparent, making it harder for companies to acquire information on the identity or hazards associated with chemical substances. When chemicals are part of larger supply chains, there is a risk that necessary information needed in terms of what chemicals are being used to produce a finished product, are either protected by company secrets, unavailable, conflicting, or the information is lost in the supply chain (Scruggs and Van Buren, 2014).

Manufacturing industries are now facing an increasing demand in regulations on what chemicals can be used in the production of finished goods. The response towards countering the problem with the increasing number of chemicals in products globally is reflected in recent years upcoming regulation programs/initiatives, where many national governments have established institutional structures for the purpose to manage the ever so growing volume of chemicals used within and outside the European Union (EU) (UNEP, 2014). The uncertainty surrounding chemicals' compositions in products has thereby resulted in regulations of substances, e.g., Substances of Very High Concern (SVHC), Registration, Evaluation, Authorisation and Restriction of chemicals (REACH), Digital Product Passport, and in organisations such as Strategic Approach to International Chemical Management (SAICM) (Regulation 1907/2006; European Commission, 2020a; European Chemical Agency, n.d.; SAICM, 2022).

Legalisations such as REACH has shifted the responsibility towards the producer, importer, and downstream users, for chemical substances that they place/introduce on the market, which are either produced or used. Previously, the society was responsible for banning or regulating the substances they knew had dangerous properties (Schenk and Antonsson, 2015; Cefic, 2021). The obligation for downstream users on declaring chemical substances in accordance with REACH or other regulations, may to some degree vary depending on what kind of downstream user is involved, e.g., formulation, production of articles, or end user. However, downstream users must comply with all requirements on registration and notification of chemical substances in the produced product articles. They also have the duty to communicate the necessary information on substances to further downstream users (Schenk and Antonsson, 2015). The regulations therefore set requirements on the product itself, which means that manufactures need to know

what chemical components the product comprises of. The legislation also could challenge such as establishing criteria for what is considered dangerous, different concentrations, quantities, consideration of trade secrets (property information and similar concepts), of where new knowledge means that new substances can be considered dangerous.

Except for legalisation purposes, there are also many reasons to why producers and consumers are interested in knowing what chemical substances, harmful or not, are present in products and in the supply chains and products. Such reason could be to increase company knowledge concerning chemicals in products and the supply chain, to be able to meet the proper conditions for recycling and waste handling, customer requirements, to boost the transition towards a circular economy, compliance, increase sales, and market opportunities. Whether companies are forced by compliance or are driving their own initiatives by investigating present chemicals in products and supply chains, it all comes back to that the information on constituent chemical are difficult to track in supply chains (Scruggs and Van Buren, 2014).

By understanding the complexity and connection between a product life cycle, what can be facilitated to improve chemical management, and what chemical substances are found in the components used to manufacture a finished product, are all important means to generate knowledge of a products environmental and human health impact. However, in order for manufacturing companies to be able to identify what chemical substances their components contain, an exchange of information in the supply chain is required.

Therefore, the aim of this study is to investigate the current readiness to disclose information concerning chemical substances in components produced by suppliers towards the manufacturing industry via a Full Material Declaration (FMD), in order to see how well-prepared supply chains are to be able to convey chemical information in goods and products. By exploring the current readiness, the study also aims to investigate the total chemical knowledge of a finished product.

Another interesting area to investigate are the potential challenges/barriers that companies must overcome in order to facilitate communication between manufactures and suppliers.

1.2 Purpose

The purpose of this master thesis is to conduct an explorative literature review and case study, to investigate the readiness of suppliers to declare/provide full chemical composition declaration for components used in finished products, more specifically on one of Alfa Laval's main products, model T15, within the business unit Gasketed Plate Heat Exchanger (GPHE). Alfa Laval is interested in this assessment since new legislation will potentially require more detailed information on substance level for products and move towards a circular economy. As a complication and examination in real time, this work includes an analysis of data sharing between Alfa Laval and their suppliers. The study thereby aims to contribute to knowledge on current supplier readiness for FMD in the manufacturing industry.

1.2.1 Research questions

- How well prepared are suppliers in the manufacturing industry to declare Full Material Declaration (FMD) i.e., of the chemical composition for their products?
- What are the abilities and willingness for a selected group of Alfa Laval's suppliers to give/contribute to FMD on/for their products sold to Alfa Laval?
- What are the existing challenges/barriers for suppliers to disclose requested information?

2. Background

2.1 The company

Already in 1883, Gustaf de Laval and his partner Oscar Lamm, established the company AB separator. Today, their legacy has emanated into a multi-international company with manufacturing and service centres all around the globe. With nearly 17, 900 employees, the company creates a global supply chain and strong regional connections, as the company's products are sold in more than 100 countries around the world (Alfa Laval, 2022a).

2.1.1 The company's key technologies

The company is a leading global provider of first-rate products consisting of heat transfer, separation technologies and fluid handling (Alfa Laval, 2022a). The company aims to enhance productivity and competitiveness of its customers by delivering sustainable products and solutions that meet requirements in the energy, food, and the marine industry. The three key technologies mentioned above are seen as the base foundation for the company's global business.

Below is a short description of the GPHE technology (Alfa Laval, 2022a): The company´s heat exchangers transfer heating or cooling from one liquid to another, and can be used to recycle heat, optimize energy consumption, cut costs, and reduce environmental impact.

Figure 2. A part of the company's heat exchanger assortment.
Source:https://www.alfalaval.com/products/heat-transfer/plate-heat-exchangers/plate-heat-exchangers

2.2 Sustainability: an important goal

Sustainability is a prominent and important issue, both within and outside the company. As an international company with many employees and facilities globally, the company has a big influence on the manufacturing industry and related sectors. As one of the leading actors within their related field, it is important for the company to recognise both its responsibilities and opportunities in accordance with what needs to be prioritised from a customer perspective, but also the future of our planet and its people. Through the company's business principles and opportunities, the company supports and pushes their work towards sustainability through innovation, aiming to accelerate the transition to more efficient and cleaner energy solutions, to drive the circular economy forward in many different sectors (Alfa Laval, 2022b; Alfa Laval, 2022c).

During 2021, the company launched a new sustainability strategy that includes what the company will focus on and improve until 2030. As described in the company's sustainability report from 2021, the sustainability strategy is divided into four different segments; caring, committed, climate and circularity. For sustainability activities related to climate and circularity, the company has set goals and ambitions concerning carbon emissions, energy, water, waste, materials, and chemicals.

There are many reasons for the company to have knowledge about what type of chemical substances that are present in their own products. The company emphasises that knowledge about chemicals in their products are not only important for improving the environment and enhancing the transition towards a circular economy, but it also serves as means to improve health and safety of everyone that potentially could be exposed to these chemicals during the product lifecycle (Alfa Laval, 2022c).

Through the company's three key technologies, the company contributes to 15 out of the 17 Global Goals adopted by the United Nations on Sustainable Development Goals for the 2030 agenda (Alfa Laval, 2022d).

3. Readiness and chemical management

3.1 The maturity on chemical declaration

As previously mentioned, there are many chemical substances circulating the world market which we know very little about. The lack of knowledge concerning these chemicals has thereby resulted in increased demand on regulation surrounding chemical substances within the manufacturing industry and associated supply chains.

Although regulations and programmes have been significantly improved during the past decades, access to information about chemicals in products (CiP) is still considered a global issue (CiPProgramme Industry Extract, 2017). Several initiatives have been taken to improve the flow of information on chemical content in general, especially for hazardous substances, but also in cases where there is an absence of information, safety data sheets and environmental declarations (EPDs). These are sometimes used to fill the knowledge gap but are often proved insufficient. The insufficiency could be explained by the fact that it appears that the handling of information about chemicals in products comes with several challenges: insufficient knowledge of new or relevant chemicals and their possible hazardous properties, which substances that are used in specific products, intellectual property, communication about the usage of substances, and transfer of knowledge, to mention some (Norden, 2011).

Fortunately, certain development is already taking place in this area, both within and outside of EU. SAICM, UNEP Chemicals, Swedish Chemicals Agency (Kemikalieinspektionen), REACH, and Digital Product Passport are only a few already established initiatives, organisations, or programmes. These international governmental organisations (IGOs) and non-governmental organisations (NGOs) has had a huge impact on the production and usage of chemicals. So much in fact, that some industries have developed protocols/templates and information transmission systems (e.g., the automotive industry, ICT) (SAICM, 2015a). Many countries and regions have also made important implementations in sanctioning laws, implementing policies, and creating programmes to achieve successful management of chemicals and waste.

Developed countries outside of the European Union have implemented major legalisations and policy initiatives as well as reforms, such as Canada´s chemical management plans, the US Lautenberg Chemical Safety for the 21st Century Act 2016, California Proposition 65, and Japan´s Chemical substances Control Act 2009 (UNEP, 2019). Even several developing countries and economics around the world such as China, India and Latin America, are in transition and are taking major steps towards implementing management of chemicals. The increasing commitment creates the potential for collaborations, replications, and knowledge-sharing, which are all important to promote successful management of chemicals (UNEP, 2019).

Transparency through disclosure and data-sharing of chemical substances in products between all stakeholders throughout the whole supply chain is an important step to ensure that companies contribute to protect the environment and human health. Unfortunately, there are few systems that are well developed and implemented that can inform about what kind of chemical substances that products consist of (CiPProgramme Industry Extract, 2017). Managing, upholding and improving management of chemicals are therefore considered critical factors in advancing the global sustainable consumption, the production of and phasing out chemicals of concern on the global market, and to ensure that hazardous chemicals do not end up in production of products. The phasing out of chemicals are also seen as a way of addressing the global pollution challenge and improving human health (SAICM, 2022).

3.2 Knowledge of Chemicals in Products (CiP)

Knowledge about chemicals in products and supply chains is, according to Mark Rossi 2014, vital in order to advancing the development of safer chemical usage and management. Without this important knowledge, businesses risk not being able to determine if chemicals of concern are present in their own products or supply chains. This knowledge gap is often more present for downstream users, as these businesses are often the ones which do not consider chemical management as part of their own responsibility or business initiative. However, as part of increasing regulatory requirements, NGO approvals, customer demand, media attention, and market opportunities, companies can no longer ignore the chemical complication. Ignorance surrounding chemicals in products might result in risks when downstream users are increasingly being held accountable for chemicals presented in their own produced products. Without this knowledge, companies are blind to what environmental and human health impacts these might result in when chemicals are part of the supply chain and the product itself (Rossi, 2014).

As transparency is growing to be an increasingly more essential tool for decision making, supplier reliability, and as a mean to clear communication towards customers, the lack of knowledge is seen as a barrier to generate these important values for modern businesses (Rossi, 2014).

Although the development of management of chemical presence through transparency is improving throughout products and supply chains, there are still reasons for upstream and downstream users to uphold or protect important information needed to accelerate the transition towards safer chemical usage. According to a study produced by Norden and authored by Nimpuno et al, 2011, interviewees from different manufacturing industries in the electronics sector expressed several types of knowledge gaps and challenges for sharing CiP information. Such gaps and challenges could include the following: (1) Disruption of information flow through intellectual property. (2) That the supply chain is huge and complex, making it hard for information to be passed on to downstream users. (3) Losing the information between the ODM and OEM, or that the ODM chooses not to forward all information needed due to intellectual property. (4) Information about Chemicals in products do not easily or accurately flow through supply chains. (5) Evolving and changing operation systems, where the latest information and regulations is constantly updating, making it hard for companies to stay updated on chemical compliance (Norden, 2011). These gaps and challenges are all crucial factors when addressing chemical management in products and supply chains.

3.3 Approaches to chemical management in products and the supply chain

According to an article produced by SAICM, authored by Rossi 2014, business strategies for managing chemicals in products and supply chains can, to a large degree vary depending on what type of downstream users are involved (Rossi, 2014). When approaching different alternatives for chemical management in products and supply chains, Rossi 2014 advocates two main alternatives: Passive and Active strategies (Rossi, 2014).

3.3.1 Passive strategy:

For downstream chemical users, the most dominant chemical management strategy is often conducted through the "passive strategy" where the core goals are, to a minimum, be compliant with governments regulation on how to manage chemicals in products and supply chains. As compliance is the minimum strive for businesses approving the passive strategy, the benefits of implementing such strategy are

defined by the upfront internally reduced costs, as businesses do not need to invest in systems capable of handling and processing information, staff working hours, or chemical management done by third parties. The essential management thereby consists of moving from one chemical of concern to another, rather than having systems or strategies for managing chemicals in an organizational and supply chain-based level (Rossi, 2014).

3.3.2 Active strategy:

For businesses to be able to create long-term value and to stay ahead of regulatory and marketing demands, the "Active strategy" is seen as an alternative approach towards a proactive management of chemicals throughout the supply chain and in products produced. The active strategy, in comparison to the passive, favours companies to transact ahead of time to make investments in knowledge of what type of chemicals are present in the supply chain, that can later be found further downstream towards the end user or consumer. The strategy thereby creates an organizational culture, that values preventive actions, rather than actions based on what that is relevant in the present. Such actions could involve interactions with governments agencies and NGOs, or to investigate from a broader scientific perspective. Actively working with identifying and avoiding chemicals of concern in supply chains and products thereby avoids cost and repair related formulation changes when businesses are forced to change means used for production through regulatory demands, NGOs, or customer demand (Rossi, 2014).

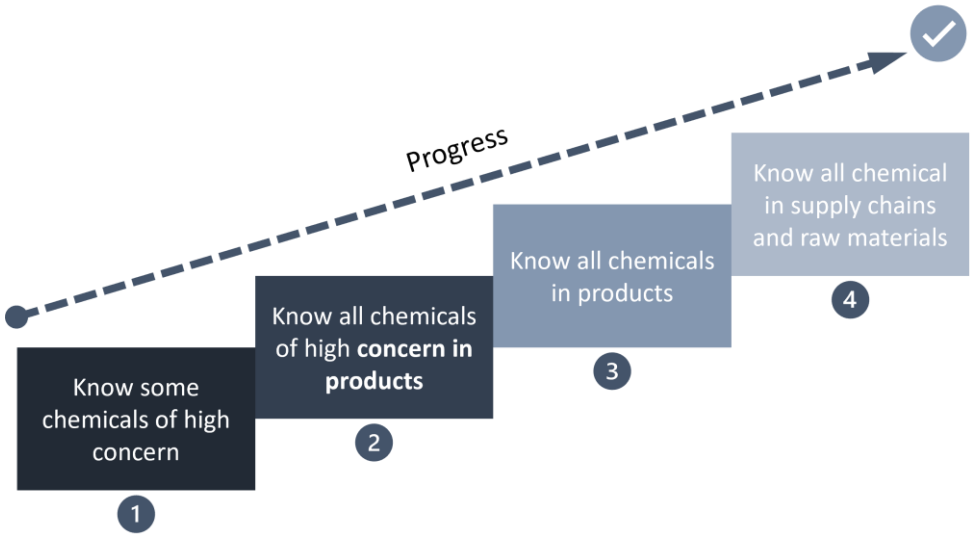

Figure 3. Figure inspired by Rossi (2014) and modified by the author describing steps towards full chemical disclosure.

3.4 Benefits and disadvantages with Passive and Active chemical management

As described in Table 1, when businesses chose to implement and work towards a "passive strategy", the low cost of investment in chemical management is seen as the biggest "benefit". Although businesses might sooner or later need to know what chemicals are present in their own products and supply chains, the passive strategy advocates businesses not to act towards sound management of chemicals until they are prompted to do so by government organisations, NGOs, customers, or downstream/upstream suppliers. This results in, according to Rossi, that companies only gain a temporary benefit by postponing what needs to be done in the present, to the future (Rossi, 2014).

Although the investments are low, the costs of the passive strategy, however, can be quite high. As chemicals of concern creates a liability for businesses, the presence of these can trigger a lawsuit, NGO campaigns, product recalls and fines, brand reputation damage, loss of sales etc. (see table 1). This scenario could potentially lead to a loss of investments from potential shareholders, which in return, could result in an immediate effect such as remarkably high direct costs for the business. This could, in the most extreme case, lead to bankruptcy (Rossi, 2014). As an example, in 2001, Sony suffered a heavy loss of sales as well as an excessive increase in costs to rework, due to forced recalls by their PlayStation console. Authorities in the Netherlands banned the product due to exceeded regulatory limits of cadmium in accessory cables, resulting in decrease of sales and reworks totalled in 150 million USD (Stanford, 2008).

The active strategy, however, can create an opportunity for companies to improve their own brand reputation, stock price, sales, and market share. By implementing an active strategy, businesses will be able to gain knowledge of the chemicals used throughout their own products and supply chains and will thus be more prepared for upcoming regulation changes and uncertainties. They would also achieve an increased beneficial transparency and be prepared to use substitutes when needed. These are all important actions when looking to generate long-term value for a company (Rossi, 2014). Although an active strategy can bring many benefits to a business, the strategy involves an upfront investment, including investments for implementing data collection systems. The upfront investments are therefore seen as an essential mean for companies to justify changes in the production and product design, which in the long term, can reduce costs and errors that a passive strategy might bring (see table1) (Rossi, 2014).

Table 1. Some examples of possible benefits and disadvantages with passive respective active chemical management, inspired by Rossi (2014) and modified by the author.

	Passive strategy	Active strategy

Some potential benefits	• Less investement in:
	  • chemical data collection, management or third-party involvement
	  • reformulating products
	  • product testing and verification
	  • supplier communication and training
		• Enhanced brand reputation
		• Increased sales
		• Regulatory demands are addressed with efficiency
		• Reliability and quality improvements throughout the supply chain
		• Easier product use and recycle
		• Savings in disposal
		• Crises management can be reduced
		• Better long-terms relationships with customers → quick respons
		• Improvements in products due to better innovation

Some potential disadvantages	• Risking brand reputation
	• Lost trust from customers
	• Risking product recalls
	• Sales losses
	• Increased cost for crisis and legal management
	• Goverment fines
	• Lawsuits
	• Vulnerable to advocacy campaigns
	• Bankruptcy
		• Investments in:
		  • what chemicals are commonly used in the supply chain
		  • management and systems to collect data from upsteams suppliers or use of third-party for the task
		  • Product reformulations - stay ahead of regulations and market demands
		  • random tests – making sure products do not incl. restricted substances
		  • Training of suppliers in better chemical selection and management

3.5 Approaches to chemical management through chemical declaration

As a response to the increasing demand from IGOs and NGOs on declaring CiP, companies are now utilizing new technologies and analytic systems to monitor upstream and downstream supply chain operations. This is done for the purpose of increasing transparency as well as for the purpose to be able to make sound decisions regarding the business' internal and external supply chain practices (Zhu et al., 2018). According to SAICM 2015b, there are three main ways of enhancing knowledge of CiP in companies. These are described in table 2 below (SAICM, 2015b):

Table 2. Table of content describing the three most common chemical declaration practices according to SAICM, 2015b, and some examples of disadvantages and advantages of respective practice.

	Disadvantages	Advantages
1. Restricted substances list based on chemicals restricted by legislation	• Supply chain must be informed every time when new chemicals are added to the list and the information system must be updated • For new restricted chemicals, the need for internal changes is immediate to be able to find substitutions or product changes • Regulation reviews and jurisdictions changes are required regularly, which are time consuming	• Process for selecting chemicals is straight-forward • Greatly reduces individual company research efforts for product sectors associations • Allows for clear target for individual companies and service providers • Making it easier from a business management and due diligence perspective through making the product legal compliance easier
2. Restricted substances list-based regulations, potential regulations, and other chemicals of concern (Preventive)	• More chemicals must be included in the information exchange, leading to higher costs. • Companies must put recourses towards following the development on chemicals that are under consideration being banned or restricted	• Chemicals selected for information exhange before regulated by force • Keeping up with regulations in a timely manner • Greatly reduces individual company reserach • Allows for clear targets
3. Full Material Declaration in the supply chain	• Expensive • Difficult to get supply chains support due to confidential information from suppliers	• Provides a comprehensive overview of chemical compositions and materials in products • Allows for immediate verification • When chemical restrictions are estimated to happen, this process allows for better material substitution and design changes • Minimizes incremental costs • Leads to less pressure from NGOs and IGOs

3.6 Full Material Declaration (FMD)

As one can understand by the information in table 2, the most efficient (although most expensive) alternative for companies when declaring chemical substances in products, is to adapt an FMD concept. Although there is no standard definition of what a Full Material Declaration (also known as Full Material Disclosure) is, through its comprehensive overview of the chemical compositions in all materials/components in the product, FMD can help companies acquire knowledge about the complex manufacturing genome, as well as help to provide full transparency into the substances present/represented within products (Assent, 2022b).

Once implemented, chemical declaration through FMD helps companies to update and facilitate the identification process of restricted substances (Assent, 2022b). In a perfect scenario, a FMD should represent 100% of what a product consists of. This means that the FMD should describe all represented materials, chemicals and substances represented in the product.

3.7 Reaping the benefits of FMD - Seagate Technology PLC

Seagate Technology PLC is one example of a company who has gained benefits by implementing an internal FMD-system. According to an in-depth interview analysis conducted by Wu Alexandra 2018, a former master student at the International Institute for Industrial Environment Economics (IIIEE) in Lund, Seagate's data collection needed to be frequently refreshed for the company to keep up with monthly customer requirements and upcoming important regulatory demands.

The company realised that the existing data collection and coordination approach for chemical management resulted in significant cost, while the company was still falling behind in correcting clients´ requests. For the purpose to simplify and make the data handling more efficient, Seagate embarked on its FMD journey in 2005 (Wu, 2018). When implementing the FMD system, Seagate strived for a 95% FMD from all their suppliers, leaving room of 5% for confidential business information (Rossi, 2014).

"*Using Seagate's FMDs and CAS, we are able to determine if and where Substances of Very High Concern are present in our products, and at what concentrations, both at the homogeneous material and article levels*." (Seagate, 2019)

By implementing the FMD system, the company could refocus its resources, as they no longer had to spend as much time on processing information that was needed for products from suppliers. Seagate could instead use the FMD system to determine the level of compliance (Wu, 2018). As an example, instead of returning to their suppliers every time a new chemical of concern emerged due to regulatory or market demands, the company could instead look through their own database in order to determine if a substance were present in Seagate's products. This made it quicker and more efficient to identify potential measures, as well as reducing work hours and costs (Rossi, 2014).

Although setting up the chemical management system and implementing the FMD required an upfront investment, Seagate saw a stabilization

in cost over time, with little to no economic fluctuations, reducing the so called "saw tooth" effect. The "saw tooth" effect, comes with prohibitive costs every time change is due to happen, therefore its graphic illustration. The red line in figure 4 illustrates how the "saw tooth" effect might look like without an FMD in place, whereas the green line represents the stabilization of resources and time after the implementation of the FMD (see figure 4) (Rossi, 2014).

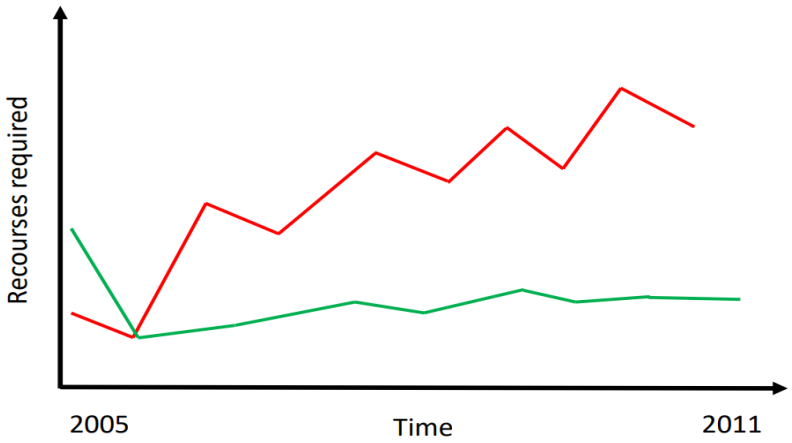

Figure 4. Figure describing the effect of implementing an FMD for Seagate (Martin Brian, 2011).

3.8 An increasing demand for chemical declaration

As previously described, for safer chemical usage, increased knowledge, and awareness of hazardous chemical substances in products, there is a growing demand for full chemical declaration for both upstream suppliers and downstream consumers which are being promoted by different IGOs, NGOs, regulations, and industry initiatives. Today, such organisations, programmes and initiatives related to demand on chemical declaration does exist. Below are some of the more important and commonly mentioned.

3.8.1 SAICM

The Strategic Approach to International Chemicals Management (SAICM) is a voluntary policy framework designed to promote the sound management of chemicals for the purpose to minimise significant adverse effects on human health

and the environment by the year 2020 (SAICM, 2022). SAICMs overall objectives are grouped under five different themes/categories: 1) the focus on risk reduction, 2) to increase knowledge and information, 3) to promote governance, 4) capacity-building and technical cooperation, and 5) illegal international traffic (SAICM, 2022; UNEP, 2019).

SAICM brought forth already established reforms in 2009, regarding transparency of information on chemicals in products, which has been identified as an emerging policy issue (EPI) by UNEP (SAICM, 2022; SAICM, 2015a). To counter the issue about transparency, programmes, and organisations such as UNEP and SAICM helps stakeholders around the world to address and improve the information concerning chemicals in products on a global scale, where the main goal of these organisations and programmes are to develop and spread knowledge, tools, guidelines, and to provide platforms for further growth and continued exchange (UN environment programme, 2022; SAICM, 2015a).

Although the goal for complete sound management of chemicals was not achieved by the year 2020, progresses and initiatives are still in place within SAICM to promote stakeholders to go "beyond 2020" to develop measurable objectives in support of the 2030 Agenda for Sustainable Development. The agenda is further explained in accordance with the fourth session International Conference of Chemicals Management (ICCM4), where this session is still open to all stakeholders (SAICM, 2022b).

3.8.2 Digital Product Passport (DDP)

The European Commission introduced the DDP as part of the sustainable product initiative directive, and the circular economy action plan in the European Green Deal, to promote the transition towards a more circular economy, and to identify material compositions of each product for the purpose that consumers across all supply chains can reuse or treat the products accordingly. The DDP also functions as a tool for providing information about products to consumers on the European market, and as an inventory for all materials, components and raw materials used in products (Svenskt Näringsliv, 2022; Renewable matter, 2022; Euroactiv, 2021).

The Confederation of Swedish Enterprise supports the idea of developing a tool such as Digital Product Passport, as this tool can promote companies to provide more transparency in their own products and supply chains. However, the Swedish Enterprise has expressed concerns regarding the purpose of the DDP. The Swedish Enterprise (Svenskt Näringsliv) points out that the policymakers need to define the sustainability challenges that are being addressed by the implementation of the initiative (Renewable matter, 2022).

3.8.3 REACH

The regulation EC 1907/2006 Regulation, Evaluation, Authorisation and Restrictions of chemicals (REACH) aims to excel and improve the protection of human health, the environment, innovation, and competitiveness of the EU chemical industry, where the REACH regulation has shifted the responsibilities towards the industry to manage and uphold the risk of chemicals. For safe handling of chemicals, manufacturers and importers are required to gather information on attributes concerning chemical substances represented and used. All stakeholders must thereby comply to register information concerning chemical substances to the European Chemical Agency's (ECHA) central database (European commission, n.d.a).

"Innovation for the green transition of the chemical industry and its value chains must be stepped up and the existing EU chemicals policy must evolve and respond more rapidly and effectively to the challenges posed by hazardous chemicals" (European commission, 2020a).

EU already has one of the best, most comprehensive, and protective regulatory frameworks for sound management of chemicals in an international comparison (European Commission, 2020a). However, as stated by the European Commission, there is always room for future improvement and further progress, as the progression remains slow, and EU is still lacking a comprehensive information base on all substances placed on the market (European Commission, 2020a). Although a wide range of international, national, and regional implementations and responses, which are in direct relation with the sound management of chemicals and waste are in place, the global governance remains scattered due to compliance and standards varying depending on regions and countries. This fragmentation has inhibited the impact and effectiveness within already established initiatives, organisations, and programmes. Therefore, according to the European Commission (2020a), both global objectives and targets are now necessary to tackle this fragmentation. The European Commission therefore promotes a renewed Strategic Approach to International Chemicals Management, that will address and empower the sound management of chemicals by strengthening international standards on chemical management (European commission, 2020a). After 20 years of chemical management, promoted by REACH, EU is now also setting new long-term visions for EU´s chemical policy framework, in accordance with the European Green Deal, to achieve a green and digital transition, where the European Union continues to play a leading role (European commission, 2020a).

In accordance with REACH, substances which we know have serious effects on the environment and on human health, are according to the European Chemical Agency (ECHA) substances which are identified as Substances of very high concern (SVHC). If a substance is identified as an SVHC, then the

substance will be added to a candidate list (ECHA, n.d.a). Importers, manufactures, or other users of substances which are on the candidate list, have immediate legal obligations to fulfil the necessary actions in accordance with ECHA to notify if the substance is present in their own products, if the substance exceeds a specific threshold, or if the substance quantity exceeds more the one ton per year (ECHA, n.d.b; Assent, 2022). Furthermore, products intended for the EU markets, containing substances of very high concern (SVHC) is also part of EU WFD. These products and their components need to be registered to a EU database called SCIP (ECHA,n.d.c).

4.Methodology

This work was conducted between January 17th and May 25th, 2022. To answer the questions at issue, the thesis uses an explorative literature review and a case study, to access and collect relevant information.

The explorative study serves as a mean to increase the understanding of the complexity of the topic at issue. The case study is conducted as an examination of one of the company's gasketed plate heat exchanger (GHPE) product, more specifically, the T15-model.

As the demand on chemical declaration in goods and services increases, an interesting area to investigate is to what extent an Original Equipment Manufacturer (OEM) can obtain information from their suppliers about chemical composition in components used in their finished goods, and the possible difficulties and challenges and barriers suppliers may have to provide future potential requirement for FMD. The result of collecting this data could serve as an indicator of how developed and systematised the data collection and sharing is in the supply chain. The result could also indicate to what extent the declaration fulfils the needs of an OEM, to in their turn meet the increasing demand on chemical declaration for finished goods. The information provided can thereby explain the degree of maturity of suppliers to obtain the necessary information and pass this on to OEMs, such as the company in question in this investigation.

The area of interest can be explored in several ways. One alternative for gathering relevant information is through a compilation of already established material, such as information gathered through government officials and other sources that affect legislation and guidelines within the area. Another alternative is to collect information from people inside original equipment manufacturers (OEMs), and/or case studies of individual products and OEMs. The different methods for gathering information have their advantages and disadvantages regarding generalization, usability, and relevance, as well as completeness in a narrower area versus level of experience. Such a study as described above, can be a combination of methods; literature review study, asking the suppliers to provide an FMD, collecting the information and data through interviews with OEMs, suppliers and the company manufacturing the finished goods or a combination of one or more methods.

Although mentioned methods could individually or in combination be relevant, a single case study in combination with an explorative literature review,

consistent with current literature on the subject in question, limits the scope and data collection. This makes it possible to either strengthen or reject facts and theories in the literature about the readiness to disclose chemical compositions through FMD, and can therefore be considered the most relevant option for investigating the questions at issue.

According to Efron and Ruth (2018), a literature review could serve as a mean to expand the existing knowledge and understanding of a topic in its present and future state. The research design for explaining the degree of maturity to declare chemical compositions within finished products, will be gathered from scientific articles and "grey literature". If relevant literature could not be found through scientific search engines, then Google Scholar has been used as a complementary source for gathering further context. Only peer-reviewed scientific articles have been considered in this study. Further documents related to the content which can be considered as "grey literature" consist of information from government documents, organisations, and collaborations between OEM and external providers to the company, such as services for material standards.

The most prominent method used for the explorative literature review was the "snowball method". When identifying promising articles, books, reports or other materials, this method provides the opportunity to scan authors' previous references and materials of relevance. This is an effective way of sourcing new materials/relevant information. Although this method will include older literature, the method is still a good way for identifying other key publications which are relevant to a subject, as these publications often are frequently referenced (Tight, M, 2017). The reason for choosing the "snowball method" was based on that the first initial literature exploration conducted at the start of this thesis, did not result in enough relevant sources to answer the questions at issue. The method proved to be an efficient way to collect relevant information, as many references used in publications came from promising sources in so called "grey literature".

This study will therefore, regardless of any disadvantages of the selected methods, be based on a collaboration with the company, a global original equipment manufacturer (OEM), for a case study in combination with an explorative literature review.

4.1 Single case-study

For this single-case study, and in order to be able to recognize and accept the strengths and limitations, the first step is to accept that the case itself is considered to be small-scale research. Secondly, a single case study can, according to Tight, M., (2017), help to unravel various complex issues and can therefore be highly influential to those involved (Tight, M, 2017). According to Tight, M, to be able to

unravel the complexity, a case study needs to contain the following five general characteristics: (Tight, M, 2017).

1. “The case study must be significant
2. “The case study needs to be “complete” “
3. “The case study must consider alternative perspectives”
4. “The case study must display sufficient evidence”
5. The case study must be composed in an engaging manner”

The format of the FMD has been developed by the author in collaboration with the OEM. The case study is conducted through the company´s own well developed communication channels that the company use when communicating with suppliers (see appendix 1).

Reasons for choosing the T15 unit was based on total turnover and margin, making this specific model one of the company’s important and bestselling products within the GPHE business. The T15 is also a relatively newly introduced product on the market (introduced in 2019), which makes this model suitable benchmark for future forecasts when new and/or upcoming models will be introduced.

4.2 100% FMD and degree of readiness

Gathering information from people working with the subject at issue on both sides – companies receiving information and suppliers providing information – and gathering information from experts within the field, is likely to increase the relevance and reliability of the study.

Information gaps may be a concern when gathering information from suppliers, as information may be more difficult to obtain from certain suppliers than others for certain types of components. There may also be geographical difficulties when addressing the willingness to disclose requested information from suppliers because of differences in business cultures, policies, legalisation, communication, and business models. There may also be differences in the completeness of the information provided.

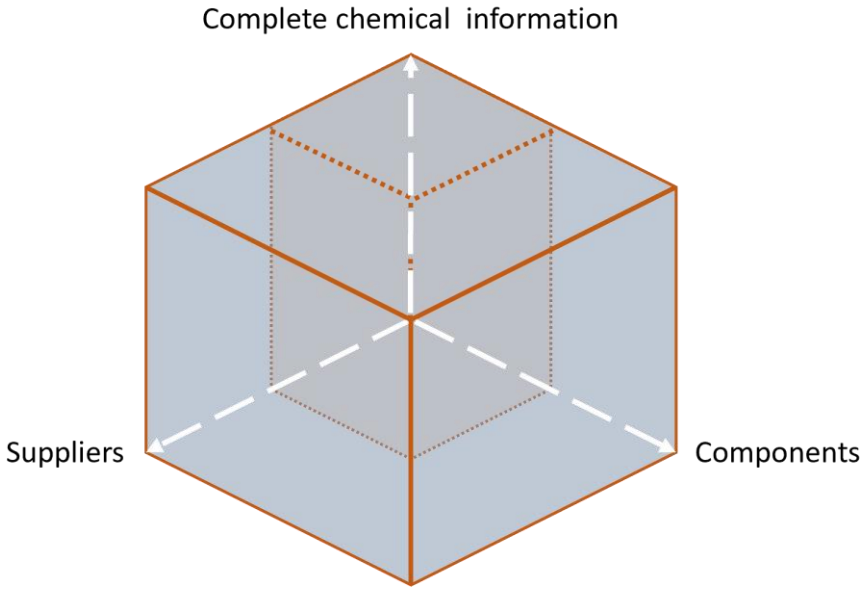

Figure 5. The figure represents the optimal outcome (100% full material declaration) when gathering information from suppliers.

The outer cube in figure 5 represents the perfect scenario with 100% complete chemical composition knowledge for chemical substances identified in the BOM-list in relation to the number of suppliers and components. The information on individual product components from respective suppliers is illustrated between two axes, while a third axis represents the degree of complete information provided. The inner cube illustrates the degree of completeness when fewer suppliers cannot provide FMD for all components. The area between the two cubes illustrates the information gap.

There are potential risks when trying to gather information for the specific case study. It is of most importance that a relationship between the OEM in question and the supplier is present. Otherwise, there is a risk that the case study may result in lack of responses, incomplete relevant information, or reluctance from the supplier to participate in survey/interviews.

The essential information and tools needed for the case study was provided by the company. When selecting a specific product for further investigation for a FMD, based on previously mentioned factors, the company concluded that the T15 GPHE model was the most relevant option for the case-study (see information in "Scope and limitations"). Figure 6 describes a broad overview of the workflow applied. The different phases in the workflow can include several steps of the work to arrive at FMD for the T15 unit.

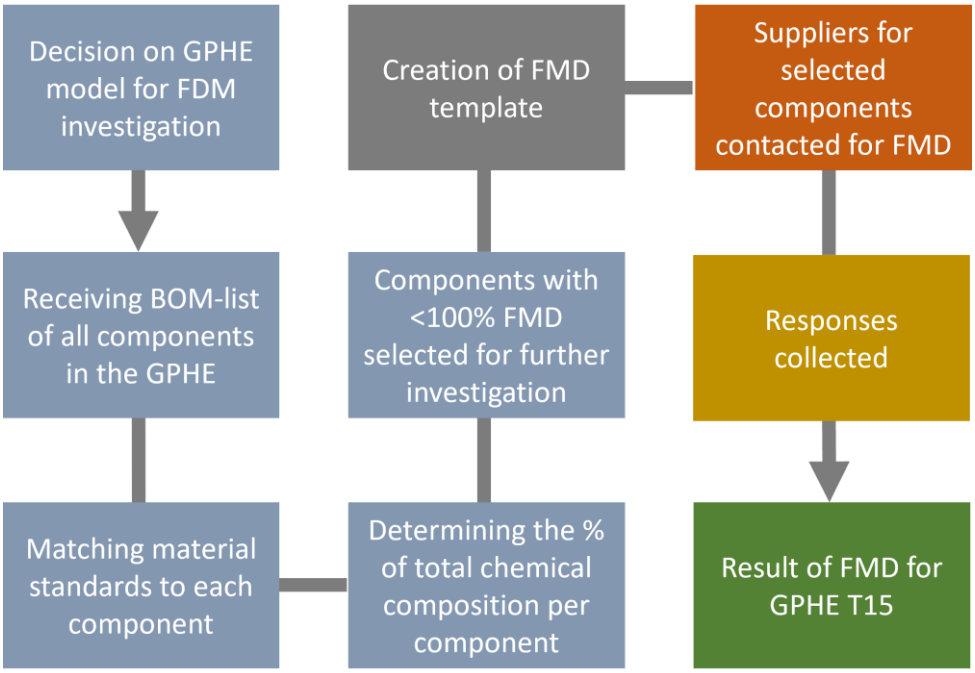

Figure 6. Figure describing the broad workflow for obtaining FMD for components provided by the company´s suppliers.

Phase 1:
To compile FMD for the product T15, the first stage was to identify which components that did not have a material standard for the chemical composition.

Phase 2:
In order to decide which components and thereby which associated suppliers should be contacted, a Bill of Materials list (BOM-list) of all present components in the T15 GPHE model was provided by the company. Business unit GPHE R&D conducted this process internally, for the purpose of being able to complete a full chemical composition analysis regarding each component represented in the T15 GPHE unit. The BOM-list consisted of all present articles in the specific T15 unit,

in what quantities and a short description of each component. To complete the BOM-list with information needed for the case study in this thesis, weight and chemicals represented in each component (according to international material standards (e.g., ISO, ASTM)) were investigated.

Phase 3:
With the help of the company´s Corporate Standards team, material standards could be designated to specific components. The data analysing process of the BOM-list in this study consisted of interlocking international material standards (Internationalising Organization for Standardization) for each individual component within the BOM-list. Because of each component's unique composition and sets of material standard, each component needed to be investigated individually to extract the unique chemical composition.

As there seemed to be an endless amount of different material standards, it was vital to comprehend that each standard represents most often only one component. Therefore, the connection between material standards and components is a vital step when determining the total chemical composition of the full product. Each material standard represents what chemical substances that the component comprises of, and in what quantity up to the allowed limit each chemical substance is to be found/represented. According to the material standard (see appendix 1), international standards therefore represent a percentage (%) of chemical substances that each individual component may contain. The programs and tools for accessing material standards was provided by the company's internal and external services. Below is an example (see figure 7) of how the identification and summary process was set up when determining the total chemical composition, using material standards for components in the T-15 GPHE model:

Figure 7. Figure describing the identification and summary process when determining the total chemical composition within components used in the T-15 GPHE business unit using material standards.

To be able to determine the total amount of chemical composition declared from the international standards within each component for the T15, the chemical composition, represented in % for each individual substance, were summed up to a total percentage for all represented chemical substances within the component (see figure 7). In cases where chemical substances were represented

with a percentage-interval (e.g., 5-15% coverage), the decision was taken together with the company, to include the highest percentage for each substance.

One important aspect to clarify, is that the total chemical percentage of compositions within each represented metal component, that already have a covered percentage represented from the initial data analysis when matching components with material standards, were considered (according to communication with the company) to already have 100% FMD. Below is an example of how the calculation was done, and what conclusion that was drawn for components with already 100% FMD:

All metal components have one or a combination of regular/standard metals, which represents the missing % of chemical composition within the component in question (see figure 8).

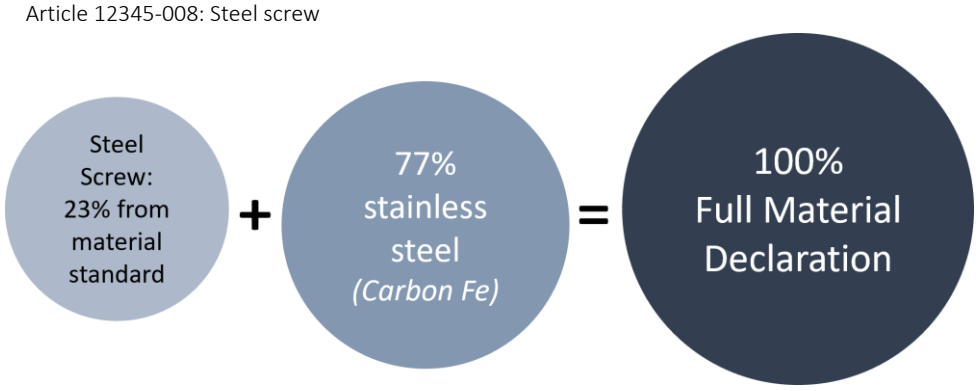

Figure 8. Figure describing how metallic components with composition from material standard are combined with a standard metallic, resulting in 100% chemical composition.

Phase 4:

Components which did not match a material standard and where no information on chemical composition was obtained, were considered candidates for further investigation. These were separated into a second BOM-list. Suppliers for these components were then identified and contacted to answer the request for FMD (see appendix 1) concerning full chemical composition declaration for their sold products. The responses from the FMD request served as the backbone to the results for the case-study.

4.3 Questionnaire on chemical declaration

To further expand relevant information explaining what types of challenges and benefits a full material declaration may bring, and to be able to answer the questions at issue, a questionnaire was sent out to 48 of the company´s suppliers relevant for GPHE products. The questionnaire consisted of three quantifiable questions that could be answered with yes or no, and five qualitative questions, where the respondents were asked to answer the questions in his/her own words. The answers received in the questionnaire were arranged into different categories for each question for the purpose to describe correlations between the answers received. In the result of the questionnaire, each respondent may have given several answers to each question (open question), and therefore the respondents answers can be found in more than one category.

As full material disclosure and full material declaration are the same thing, the author decided to use the term full material disclosure for the FMD request.

4.4 Semi-structured interviews

By capturing why material declarations, in components supplied to the company, is important for the company, some semi-structured interviews add further relevance to this study by contributing to a better understanding of benefits and advantages of full chemical declaration, and what resources are needed, for both the company itself and their suppliers. Two semi-structured interviews were conducted with internal personnel.

Using semi-structured interviews have advantages. The researcher has control over the topic and what types of questions that need to be answered. The method makes it easier for the interviewer to ask follow-up questions to further penetrate the topic (see appendix 4) (Bryman, 2018).

4.5 Limitations

When searching for relevant literature to be included in the explorative literature review, only relevant information from scientific articles, government documents, organisations, and information from collaborations between the OEM and an

external provider will be included. The case study will only include one specific article/model of the GPHE unit and will therefore exclude all other products within the company's industrial GPHE line. The specific model is chosen by including criteria regarding largest net sales, biggest market and by the fact that the mapping/survey will be limited to the production at the Lund facility. When addressing the suppliers, only the first tier (tier 1) material suppliers for the specific GPHE-product (referenced further to as "supplier"), will be included in the study. This because, of the reasons that it is the company's suppliers' responsibility to collect information concerning chemical compositions within their own suppliers. It is also important to mention that the information provided for the result cannot be generalized for all products present for the OEM, as each specific product needs to be investigated in its own way.

4.6 Ethical reflection

When conducting a thesis that is discussing the maturity in the supply chain to share sensitive information concerning their own products to requesting customers/manufacturing industries, there is a risk that suppliers might feel pressured or obliged to hand over sensitive material.
If the suppliers know that they fulfil all requirements, it can be assumed that the supplier has nothing to lose when disclosing the information, given that they feel confident that the information provided will be kept protected, through for instance a confidentiality agreement.

Lack of systems in place, lack of knowledge about rules and regulations and lack of resources could be barriers that makes it difficult for suppliers to provide certain information about chemical composition in their products. These "shortcomings" can create a feeling of being perceived as less ready to meet the demands, from both the customer and authorities and organisations.

At one hand, if the supplier is reluctant or refuses to share the requested information, this could be a reason for the customer to anticipate that the supplier does not fulfil the requirements or is not mature enough at the point of time.

On the other hand, if the supplier does not fulfil the requirements, but is willing to disclose sensitive information, showing both transparency and responsibility, then the customer could potentially help the supplier to meet the customer requirements.

The relationship between companies and their suppliers can either be strengthened or weakened by the demand to disclose information. A possible

challenge is that suppliers for various reasons lack the knowledge about chemical content or have incomplete information due to difficulties in obtaining information from their own suppliers and are reluctant to disclose information that is patent-protected or intellectual capital.

Another ethical reflection that can arise when companies are given greater responsibility for mapping chemical substances in their own products, are the difficulties regarding who that is responsible for environmental and health problems, as well as the costs required when consequences arise from usage of products. When chemical substances break down and ends up in the environment, the responsibility for potential measures might differ depending on country and the type of company involved. Historically, one can see a tendency towards companies "greenwashing", where larger companies are successful in meeting all formal requirements set by regulations and legislations when the product is manufactured and sold, but relinquishes all responsibility when the product after the it is handed over to the consumer. This, in return, leads to that companies do not necessarily make the investments needed in a complete convention, where the entire product life cycle is included, but instead hands over the responsibility to downstream users in the consumption chain.

Research for this thesis has been conducted in accordance with ethical guidelines of the Swedish Research Council (Vetenskapsrådet, 2017).

5. Results

5.1 What is the degree of readiness on declaring chemical composition through FMD for the company's suppliers?

Investigating 100% FMD for the T-15 unit

During the identification stage for components which did not already represent 100% full chemical knowledge, the results showed that the specific T15-unit has a total coverage of 89.1% chemical composition. For components to be considered to have a 100% FMD, all chemical substances need to be identified (see figure 8). All components which did not include any material standard references and/or standard metallic compositions connected to the component, required further investigation (see figure 9). As described in figure 9, 10.9% of components present

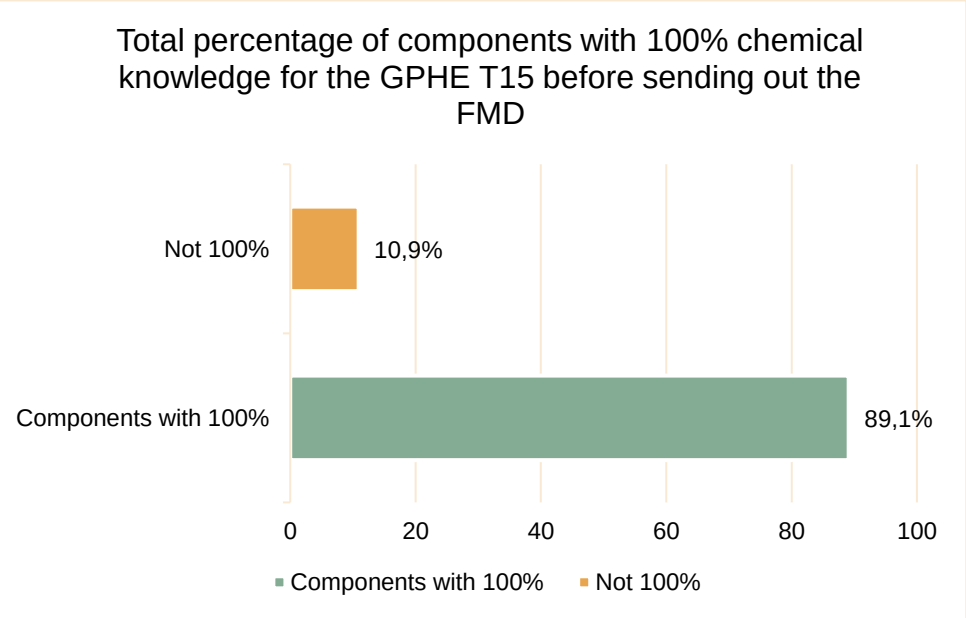

Figure 9. Figure describing the total percentage of components with 100% chemical knowledge before sending out the FMD.

in the T15 did not fulfil all requirements for full chemical composition. The 10,9% corresponds to components delivered by five suppliers.

Based on previously mentioned results, components with associated suppliers who are in the 10.9% interval (see figure 9) were asked by the author and the company's sustainability group to answer the FMD containing substance name, Chemical Abstract Service Registry number (CAS-number)[1], European Community number (EC-number)[2], and concentration in % (see appendix 1).
The results show a 40% total answer ratio for suppliers who filled out the correct requested information (see appendix 1) and responded with a FMD for the

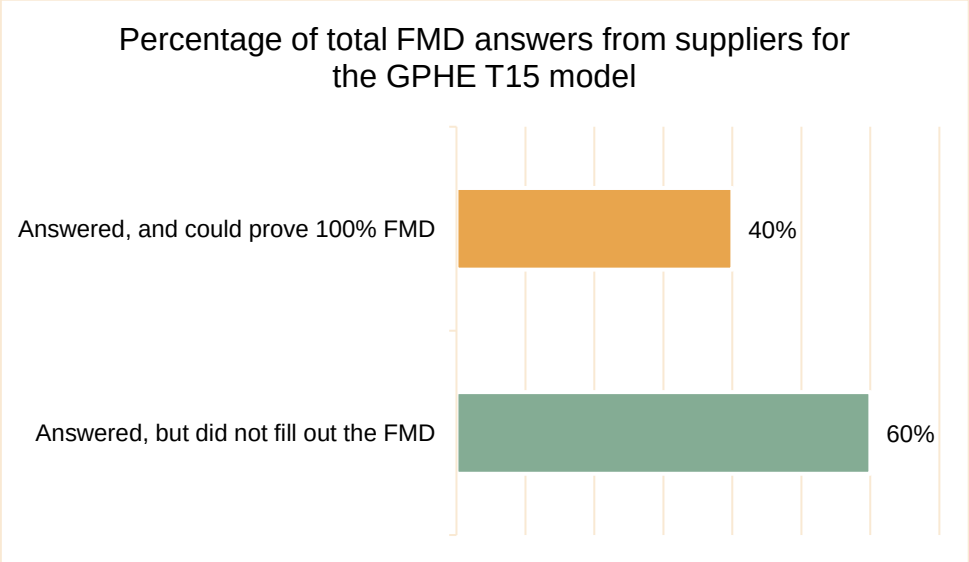

Figure 10. Figure describing the total percentages of answers provided by the FMD request, where 60% did answer but without filling in the FMD, and 40% answered and could prove FMD.

component/components used in the T15-business unit, where all requested information was included (see figure 10).

[1] CAS Registry Numbers (often referred as CAS Numbers) are universally used to provide a unique, unmistakable identifier for chemical substances.

[2] The European Community number (EC number) is a unique seven-digit identifier that was assigned to substances for regulatory purposes within the European Union by the European Commission

Out of all suppliers contacted, 60% did respond to the request but did not include doing so by answering via the FMD. Instead, these suppliers referred to already well-established agreements between the company and the supplier, referring to the company's own restricted substance list (RSL).

5.2 FMD for the T15

As a response to the number of suppliers represented within the 40% who answered the FMD request with full declaration of substances, chemicals, and materials included in the (see figure 10) the T15-unit increased from 89.1% total chemical knowledge to a total of 93.2% FMD, based on number of components used. This also resulted in a positive decline from 10.9% components with unknown chemical knowledge, to 6.8% (see figure 11). The total FMD can be calculated by dividing the number of components without 100% FMD with the total amount of components.

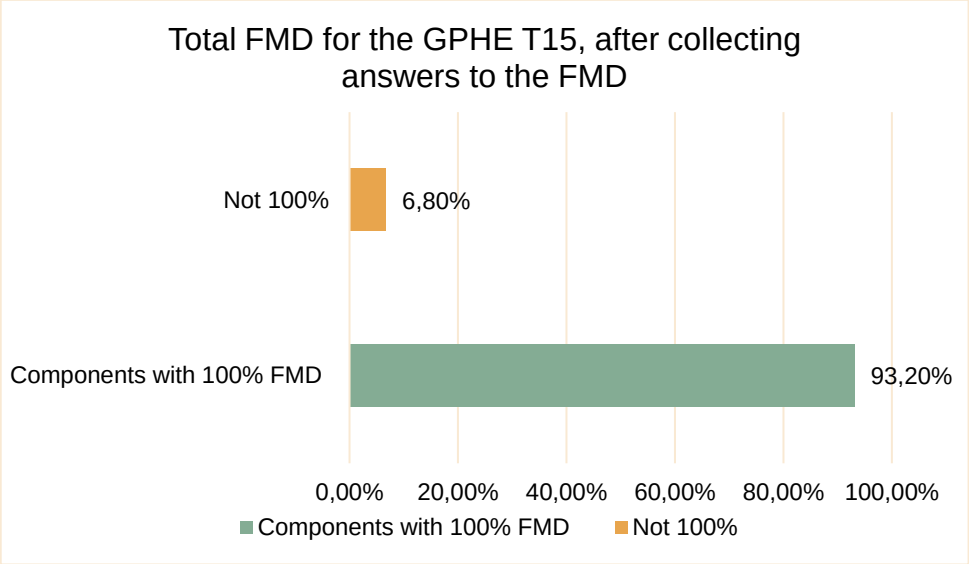

Figure 11. Figure describing total percentage of FMD based on the numbers of components in the GPHE T15 model, after collecting responses from suppliers representing the 10,9 % unknown chemicals.

5.3 Reasons for suppliers not answering the FMD request

As described under section 3.1, there could be many reasons for suppliers not to disclose information concerning chemical compositions within their own products (Norden, 2011). When asked to disclose information on chemical composition through FMD, one supplier expressed that the company had received similar requests from other customers, but that those customers managed the request differently. How this was managed differently was not explained in the answer. According to the supplier, the supplier is not obliged to provide an FMD breakdown of the articles delivered to the company, as the supplier already provides relevant information according to the company's internal guidelines and REACH. As the supplier already follows the company's guidelines and REACH, the supplier thereby claims that there are no hazardous chemicals or substances of high concern present in their components/materials used. The supplier expressed that they would not in any way disclose chemical information to any customers, as the information is intellectual property.

Another supplier stated that the reason for not answering the FMD was because of communication difficulties in the upstream supply chain. Although the first-tier supplier had not received any answer from the OEM, the supplier expressed no concerns regarding hazardous chemical substances. Therefore, as the supplier is not the OEM of the component in question, they claimed that the request for FMD must be passed along many stages in the upstream supply chain before the information can be accessed by the supplier, and further passed on to the company. The supplier also explained that the article in question would not include any trade secrets, intellectual property, and that it is the company investigated in this study responsibility if the component would contain nonlegal or hazardous substances.

One supplier reference REACH as the main source of what information needs to be disclosed, but also points out that security and confidentiality are key factors. As the information asked for is a trade secret according to the supplier, the supplier needs to be assured that the information shared is handled safely and not reviled to competitors, or to stakeholders that has no need for the information. The supplier expressed that awareness about disclosing information is of importance, but that they do not share the opinion that the only way forward should be through FMD. Another supplier for the company's standard paint also expressed that disclosure through FMD would not be an option, as the supplier would have to reveal formulas, which are trade secrets.

5.4 From a supplier perspective, what are the reasons for declaring and what challenges can be identified?

As described in the literature background, the increasing demand on chemical declaration requirements for chemical substances in products (CiP), has resulted in that the manufacturing industry now faces an increased need for transparency on data sharing throughout the supply chain. EU's REACH and new upcoming initiatives like Digital Product Passport and the Sustainable product Initiative, are pushing the agenda into the future, setting new long-term goals for sound management of chemical substances in products (European commission, 2020; Norden, 2011; SAICM, 2022). As transparency is a much-needed factor to secure the sound management of chemical substances in products, companies need to ensure proper data sharing for both upstream suppliers and manufacturers, and for downstream consumers (Norden, 2011; SAICM, 2022).

This section focuses on how to clarify and fully understand if information regarding chemical declaration for products and components are difficult for suppliers to identify and communicate towards manufacturers and customers. This section also aims to identify if the suppliers see an increased need in chemical declaration, and why the information risks being lost or partly disappear in the supply chain. The information is based on the company's suppliers' own opinions and thoughts on what challenges, barriers, and main reasons that exists for providing chemical composition declaration for all of their own articles (see appendix 2). The response rate was 31%, where 15 out of 48 suppliers responded. As described in the chapter Methodology 4.3 when presenting the result, the answers are arranged into categories (e.g., environment, compliance etc), where each category represents the type of reason or opinion that the answer can be considered belonging to. Each question ends with an analysis of the most important results.

5.4.1 Do the suppliers see an increase in chemical declaration?

When asked if suppliers experience an increasing need/demand for chemical declaration for their products, seven out of 15 answered yes and eight answered no (see appendix 2). The "yes" answers can be categorized into the following four categories (see question 2, appendix 2):

1. To safeguard the environment
2. Regulation and legislation from different authorities and organizations
3. Environmental Health and Safety (EHS)

4. Market demands

Two suppliers regard environmental reasons being one of the driving factors towards an increased demand on chemical declaration. This increase is said to be due to product impact on the environment, and that the public thinks that manufacturers such as themselves should further consider the environment more than they previously have.

Five suppliers express that the increasing pressure from authorities and intergovernmental organizations pushing regulation and legislation forward are the reasons for the increasing demand for declaration of chemical composition. One supplier expresses these authorities to be such as the United Nation, with its Sustainability Development Goals (SDGs), that are working harder to identify and exclude hazardous substances, and that companies now are following these regulations to have a stronger environmental profile. Other suppliers responded that the increase is due to the fact that more regulations are set into force, or that new substances are being added into already existing regulations.

Two respondents say that the increase in chemical declaration is connected to an increased focus on the Environment, Safety, and Health (ESH) aspect. One respondent mention that the company sees an increase in ESH on all levels, whereas the other respondent thinks the increase is due to the general trend towards both sustainability and health/safety conditions for workers.

One supplier responded that the main reason for the increase is due to higher market demands on environmental friendlier products and quality.

One supplier responded that the increase is due to higher customer demands for inquiries about chemical declaration.

As already stated, eight of the total 15 respondents, answered “no” to the question if they see an increasing demand for chemical declarations. Only two out of the eight motivated their answers. They explain that they do not see an increase in chemical declaration due to the lack of chemicals in their own production process, or that most of their customers do not need to know the information.

When analysing the answers, the main reason for an increase in demand for chemical declaration is regulations and legislations. Environmental and EHS reasons are the second most mentioned reason.

5.4.2 What are the beneficial effects of mapping chemical substances?

When asked what beneficial effects the suppliers experience by mapping chemical substances within their own products, ten out of 15 suppliers answers can be categorized into the following four categories (see question 2, appendix 2):

1. Awareness and knowledge of product content
2. Easier administration
3. Compliance with regulations
4. Ensure quality and safety of the environment

Looking at the answers to this question, "awareness and knowledge of product content", and "ensure quality and safety of the environment", seem to be seen as the most beneficial effects of mapping chemical substances. Three respondents expressed that it would help create awareness of what kind of chemical substances their product comprises of. One supplier said that it is imperative to know what substances the company are using to be able to reduce/minimize the risks associated with the substances, and if possible, use substitutes less "dangerous". One supplier also pointed out that the increased awareness can result in the ability to make wise choices when choosing their own suppliers.

Three of the respondents said that the benefit is that they can ensure quality and safety of their products and protect the environment.

Two suppliers mentioned that a mapping of chemicals could ease the administration when registering. However, one supplier pointed out that since they are a small player and that their ability to summarize and understand chemical substances is limited and therefore support for this would be needed.

Two respondents expressed that compliance towards regulations are the reason for mapping chemical substances. They think that the mapping contributes to ensuring that the product used by their own customers comply with all published regulations and legislation, and that they get a better overview when new regulations need to be implemented.

Interesting to note is that one supplier claimed that what is important to ensure is that products comply with published regulations, but that mapping the chemical substances in their own products does not seem to be necessary. At the same time, this supplier answered "yes" to if they see an increase in need/demand for chemical declaration for their own product. This answer has been added to the category "Compliance with regulations", as the statement is clear on this point, but the author is aware of the fact that the answer can be considered contradictable. However, the author has chosen to present the answer as a result as it may be of relevance for the company.

5.4.3 What are the reasons for sharing information on chemicals in products with customers?

10 out of 15 suppliers answered the question about what the reasons for sharing information with their customers concerning chemical substances in their own products are. The answers are categorized according to the five categories below (see appendix 2):

5. Enable customers to make informed decisions
6. Customer requirements
7. Quality and safety
8. Compliance with regulations and legislation
9. Information exchange and transparency
10. Environmental concern

The result from this question shows that most of the respondents (four) point at information exchange and transparency as the reason to share information with their customers. One supplier mentions that easy information exchange and good data quality leads to transparency and good customer relationship.

The second most important reason for sharing information with customers is to meet customer requirements. Only one respondent motivates the reason for information sharing with an environmental concern and one says that the reason is to enable customers to take informed decisions.

5.4.4 To what extend are the suppliers in this survey able to declare FMD for produced products?

In total, 15 of 15 answered this question. The answers were divided into yes, no, and partly. The result is presented in figure 12.

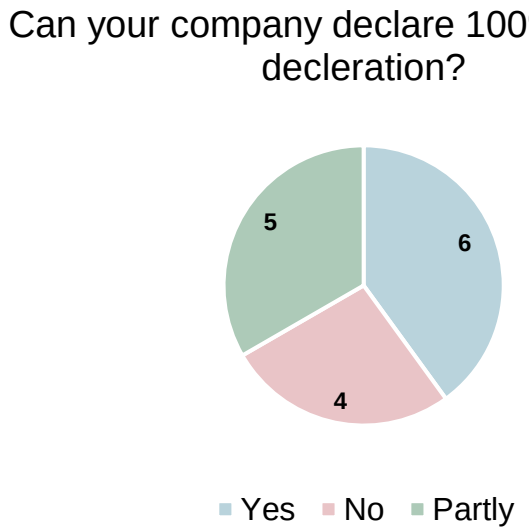

Figure 12. Figure describing suppliers' ability to declare a 100% chemical declaration for products towards Alfa Laval.

5.4.5 Challenges/barriers for suppliers when declaring chemical declaration

As described by Norden (2011), depending on what type of manufacturer you ask, different industries experience different challenges/barriers, and knowledge gaps when sharing CiP information throughout the supply chain (Norden, 2011). To understand upstream suppliers' experiences regarding what challenges and or barriers they may encounter when declaring chemical composition, a question about this was included into the questionnaire (see question 5, appendix 2).

This question is of high importance regarding understanding the conditions for suppliers when declaring chemicals. When analysing the answers, it was clear that the answers span over a wide range of challenges and barriers. It was therefore decided to not categorise these unlike what was done for the other

questions. It was simply difficult to find enough commonalities in the answers. Had the answers been categorised, there would be a risk losing important information.

Below is therefore a description of what type of challenges and barriers that the answers revealed. However, for the benefit of the reader, the answers have been put together in a logical order. In a few cases the answers have been shortened.

According to the respondents, the following challenges and barriers exist:

- It is a challenge when a supplier has a very large selection of articles, which they do not produce themselves. This in turn, results in that the information flow in the supply chain becomes a major barrier. The information flow is also referred to as a challenge to collect/receive complete data.
- Administration to handle and process data and information, especially if chemical declaration is requiring investigation of auxiliary materials, or packaging. The administration work could also increase the price on components and therefore influence the cost for the product.
- Information that can be considered as intellectual property poses a barrier.
- Some materials are complex in their composition, making it a challenge to declare.
- If declaration is not required by law, smaller and local suppliers are not able to provide the data needed.
- Although sometimes the data is collected, the challenge is to understand the effect that the chemical substances can have on the environment when being part of a component.

The above information is well in line with what the explorative literature is describing as challenges and barriers that exist. When comparing with what has already been presented in chapter 3.1 Literature background, Nimpuno et al, 2011, list five challenges and barriers. The result from the questionary reflects four out of five of the challenges and barriers mentioned.

Although the sample in this survey is based on 14 out of 15 responses from 48 sent out questionnaires, the answers provide a good understanding of challenges/barriers that suppliers experience when declaring what chemicals their products contain.

5.4.6 How can customers support/contribute to chemical declaration?

The question about how the suppliers think that their customers can support/contribute to chemical declaration was answered by eleven out of 15 respondents. The answers can be categorised into the following seven categories (see question 5, appendix 2):

1. Clear communication of what is being asked for
2. Easy to use tools
3. Minimising requests on unique chemical investigation
4. Protect intellectual property
5. Requiring higher demand on chemical declaration
6. Delivering certificates
7. Cooperation

Two answers address the communication between the customer and themselves. One supplier said that the questions asked must be written in such a way that personnel without expertise can understand what is being asked for.
Another way to support suppliers in providing information needed would, according to two of the respondents, be to implement easy-to-use tools. One of these respondents pointed out the importance of, to at the same time, be able to meet the level of expectation in protecting intellectual property.

Another answer indicates that support from customers could come from delivering certificates for steel and additives, and one respondent is simply mentioning cooperation as support.

One supplier said that they do not know how the customer can support/contribute to the mapping.

An interesting perspective becomes present through two of the answers; it is important that customers know what they are asking for and why, as sometimes what is being asked for is already covered by existing chemical legislation, such as EU REACH.

Interesting to note is that four suppliers' responses are contradicting each other. Two of the suppliers want the customer to minimise requests on unique chemical investigations, whereas two other suppliers are saying that a higher demand on chemical declaration would help.

Two answers are not possible to draw any conclusions from as the answers would require explanation from the suppliers.

5.5 The company's own opinions on the importance of suppliers being able to communicate chemical declaration

As described in the previous section, suppliers expressed what types of challenges and recourses that are needed for declaring chemical composition for their own products. This section aims to answer what the company thinks are the benefits and advantages of chemical declaration, and what resources are needed, for both the company itself and its suppliers. The result is based on interviews with two employees. The following reasons were expressed:

To be able to promote and achieve the company's sustainability strategy goals, if future regulations and legislations will include demands on FMD, the company see a potential increased need to in the future be able to declare chemical substances in components used in the company's finished products. It is also important for the purpose to know what type of impact these substances may bring to the environment and human health. By keeping a close eye on chemical composition in their own products, the company can align with their own business integrity and transparency and make sure that they fulfil current rules and regulations. Suppliers who already today can declare chemical composition will have a competitive advantage by qualification, over suppliers who cannot provide chemical declaration on their components.

The respondents believe that the ability to provide chemical declaration, can contribute to increasing compliance, for both parties, but that it at the same time probably would result in heavy administrative work, at least until a common tool for mutual sharing of data is developed and implemented.

When asking what kind of challenges or barriers the company thinks that their own suppliers might encounter when asked to declare chemical compositions for components, respondents expressed concerns that the information needed to complete the chemical declaration might get lost in the supply chain.

According to the interviewees, recourses within a number of functions are needed to be able to implement a declaration system. Material specialists, development specialists, IT-personnel and sustainability-personnel need to be added. The time for such a system to be implemented are dependent on priority in recourses.

5.6 Result analysis

5.6.1 Case study

When analysing the results for the single case-study, the conclusion is that the results to why the suppliers are not able or willing to disclose information on what chemical substances are represented within their own products/components used in the GPHE T15 model, correlates well with what is stated in the literature background about why knowledge about CiP is hard to communicate and receive (Norden, 2011; Rossi, 2014).

As described in the result, 60% of the suppliers that were asked to fill out the FMD on specific components for the company investigated in this study, did not answer by filling out the form, but rather choose to answer via email or per telephone. For these suppliers, the most common reason for not providing the requested information, was that they consider the information as trade secret/intellectual property. This indicates that these suppliers are concerned that if revealing the data, it could impact their competitive advantage and subsequently their business. Another common denominator among these suppliers is that they refer to either the company's internal guidelines (restricted substance list, RSL), and/or already well-established regulation and legislation such as REACH, as a reason not to fill out the FMD request. An interpretation of this result is, that by meeting current regulation and legislation, the suppliers avoid having to make further investigation of any chemicals in their products outside current regulation and legislation. This results in that the company might have to simply trust that these suppliers fulfil the same. It will, however, not help the company to fully understand which chemical substances the components contain, nor to what extent/concentration. This will in return impact the company's ability to provide FMD for their finished goods.

One positive aspect about the data collection in the case-study, is absence of data gaps. All suppliers asked to answer the FMD request, either did so by filling out the template, or by explaining the reasons for not fulfilling the request, thereby strengthening the relevance of the case-study.

As described in Figure 11, after receiving responses from all requested suppliers related to the T15 unit, the product has a total FMD of 93,2%. Although the results in this work cannot be generalised and applied for all of the company's products and key business technologies, the result gives a present indication on the situation for the GPHE products.

5.6.2 Questionnaire

The result from the questionnaire correlates well with that what is stated in the literature background. When government bodies, initiatives, programmes, NGOs and IGOs, and customers are pushing the need for chemical declaration forward, there are both external and internal reasons to provide a full chemical declaration. One such reason mentioned is the information flow upstream. As one respondent is pointing out, with more than one million different articles provided by different sub-suppliers, the information flow becomes a challenge.

Looking at if the geographic location is a contributing factor to how the suppliers answered to the question about if they see an increased need/demand for chemical declaration, suppliers outside of EU answering no to this question is slightly exceeding the suppliers located in EU that answered yes.

Of the respondents answering yes to the same question, only one is located outside EU. For those suppliers who answered yes to the question if they see an increase, a vast majority (six out of seven) suppliers are located within the EU.

Although the seven respondents expressed many different reasons for the increase in need/demand for declaring chemical declaration, eight suppliers responded no. The fact that a majority of the respondents do not see an increase, could be dependent on what the company in question produces or distributes. According to the results, almost all suppliers who responded no, are either manufacturers or resellers of steel related products or components, where a material standard for chemical composition already exists.

For the seven suppliers who answered yes to the question whether they see an increased need/demand on chemicals declaration, five are in Europe. As stated in the explorative literature review, Europe already has one of the world's most successful systems for handling chemical substances. When more knowledge is added and shared, and awareness among various actors and the public are increasing, this could be an explanation as to why European companies see an increasing demand in chemical declaration.

As the company strives to align with their own business integrity, increase the transparency and make sure that the company fulfils current rules and regulations, suppliers who are willing to share their own declared information towards the company, has the chance to achieve a competitive advantage and build a healthier relationship and thereby prepare for potential future legalisation which could include demands on FMD. Another coinciding topic between the company and the suppliers are, that the ability to declare chemical composition could benefit both parties, but only if the administrative work and security concerning trade secrets/intellectual property can be addressed in an effective way. Both the company and the suppliers mentioned that an easy-to-use tool could be an effective solution.

6. Discussion

6.1 Why FMD is important

To access and increase the amount of information about chemical substances in products (CiP), transparency through declaration and data-sharing between all stakeholders throughout the supply chain, is an important step towards protecting the environment and human health (SAICM, 2022). Although there are few systems which are well developed and implemented widely enough, and that can inform what kind of chemical substances products consist of, according to Rossi (2014) there are still ways for companies to improve the chemical substance control of their products, by contributing to a better information flow throughout the supply chain and to downstream customers (Rossi, 2014). Therefore, the aim of this study is to investigate the current readiness to disclose information concerning chemical substances in components produced by suppliers towards the manufacturing industry via a Full Material Declaration (FMD), in order to see how well-prepared supply chains are to be able to convey chemical information in goods and products. By exploring the current readiness, the study also aims to investigate the total chemical knowledge of a finished product.

The increasing demand for better control of which chemical substances that end up in the environment and in humans, puts higher demand and expectation on manufacturers, both for finished goods and components. The wider community wants more environmentally friendly products and expect more from these actors, as well as from different authorities and regulatory bodies.

Summarising what this study comes down to, is if it can be expected of manufacturing companies to be able to 100% control what chemicals substances their finished products contain, and what challenges one might experience when striving to improve the readiness for completing an FMD? The study also adds a perspective on potential ways for companies and their suppliers to prepare for future FMDs. This in return, reveals another question: in order not to settle for a passive strategy for chemical management, do manufacturing companies need to accept a somewhat lower percentage of declaration of chemical composition through FMD, and can other means be accepted to secure the missing percentage of substances?

Like Rossi (2014) describes, there are two different business strategies for companies when managing chemical substance control in products and in supply chain - passive and active (Rossi, 2014). All suppliers inside and outside of EU in this study, seem to follow the necessary regulations and legislations set by authorities such as EU REACH. With a few exceptions, most of the respondents describe that they see value in mapping and sharing information concerning chemical substances, for the purpose to protect the environment and human health. Although all suppliers in this study seem to follow regulations and legislation set by authorities when selling products used to produce the T15 unit, the regulations and conditions for what type of chemical substances are allowed can still differ greatly between countries or regions as manufacturing and usage of chemical substances are embedded in a global trading system. However, despite that regulations and conditions might differ between countries and regions, it is important that manufacturers can guarantee that their products are following legal demands in the country they export to. Producers and importers should also comply with regulation and legislation on bans and restrictions if necessary (KEMI, 2022).

Based on the result in this study, one assumption is that companies' ability to share the requested information is dependent on factors such as size, geographical location, applicable rules, regulations, and what type of products they produce and in what quantities, and the knowledge about the environmental effect of chemical substances. However, it seems that the size of the company is one of the more decisive factors determining the ability to declare chemical compositions for every individual article. The size can be regarded as both a positive and negative aspect. If a large company has a larger number of produced or distributed articles, and do not have a well implemented internal FMD system, large recourses are needed for the identification process for every single article. As an example, one supplier expressed that the company have over one million articles which they do not produce themselves, making it hard to provide chemical declaration for every specific product. However, larger companies also have more recourses to spend, which can be used as an upfront investment to identify and implement a system for the purpose to make administrative work easier and to avoid the so called "saw tooth" effect (Rossi, 2014).

For smaller players, the challenge is rather related to the need when new regulation and legislation are announced and needs to be implemented, having to allocate resources by re-organising/adding temporary resources to handle the administrative work, which in return causing a higher cost. As one supplier pointed out, since the company is a small player, their ability to summarise and understand chemical substances is limited. Therefore, the company needs support to be able to complete the request for chemical declaration. Being a small supplier, support from larger customers could help to ensure accurate input towards the customers. This could in return generate improved relationship and information flow as well as mutual business advantages, such as better reputation and sales increase. For

smaller companies which are in a rapid and constant development phase, an early strive for an active strategy could help the company to adapt current and future regulation and legislation, or even prepare and facilitate an internationalisation process.

As mentioned, when investigating FMD for products, there is a probability that the declaration will not provide 100% FMD for all components used to produce a finished product, and thus a certain percentage will be missing. This because of for example trade secrets/intellectual property, disruption of information flow in the supply chain, or simply unwillingness to disclose the missing information. For this missing proportion, one must find mutually accepted methods which make the companies involved feel like they have equally much to gain. As some of the respondents point out, an important part of managing and improving the flow of information in supply chains is to improve the interaction between the customer and supplier. Sharing data between customer and supplier, could be done through a shared system, which is easy to access and use, and that guarantees that the information cannot be disseminated to other companies that uses the same platform.

If regulation bodies such as EU REACH forces companies by law to disclose information concerning chemical substances in their products, there is a risk that opportunities for competitive advantage will stagger or even removed. To counter this risk, the forced implementation could be solved through providing "rewards" to turn the forced implementation into an advantage for companies willing to disclose information. Such rewards could include subsidies, government grants, tax relief, possibility to be granted opportunities to establish new premises, and so on.

Instead of expecting improvements from their suppliers, manufacturers of finished goods should perhaps show interest in investigating further what components could replace the ones that are not possible to map and redirect their investments to accelerate the change. By doing this, the manufacturers get closer to adopt an active approach and at the same time signal that it is a common responsibility for upstream and downstream actors to control which chemical substances that end up in the environment.

The process for gathering information could start already at the purchasing negotiation. By communicating expectations on chemical declaration at the start of the relationship, the company investigated in this study can identify suppliers who do not meet the requirements. An early communication could also capture suppliers who are not willing to disclose information due to reasons such as intellectual property or trade secrets and initiate a discussion about a third-party certification as an option to ensure that no chemicals of concern is present in the product (in accordance with applicable regulations and legislation). By doing this, the company who sets the requirements on FMD, approaches a more active strategy, by introducing preventive methods, thus reducing administration and cost

for all parties. Transparency, regular communication and follow-up between the customer and supplier, will generate a positive effect. Knowledge gaps concerning chemicals which are yet to be identified, and for which we do not know how hazardous these might become when part of a product, can be more quickly be closed, contributing to increased knowledge about CiP. Through long term partnership and maintained relations, both parties could protect their businesses.

There are examples of companies driving the development in different fields related to environmental issues by openly sharing their own findings, data, and progress in development. Companies striving to help create transparency for the benefit of the environment and humans could benchmark how other companies through data sharing, drive the development of solutions to meet this purpose. Such examples include research in the pharmaceutical industry and car manufacturing companies when developing safety systems and electrical vehicles. As these companies have previously shown, sharing information could lead to an opportunity in establishing oneself as a company which strives towards a higher purpose.

Although manufacturers may have access to the total percentage of chemical substances in components representing a finished product, there are still uncertainties concerning how the composition of these can affect human health and the environment when the product approaches the end of its life cycle. The percentage of different chemical substances can vary between different components, resulting in that the effect of different percentages of chemical substances may differ, depending on how the finished product is handled during its usage/life cycle. Although 93.2% of components of the T15 unit in this study already comply with established regulations and legislations via international standards, all represented chemical substances may nevertheless still pose risks when these are broken down and stored in the environment. The chemical composition represented in percentage of each component can thus be considered problematic, as the hazards and risks associated with each chemical substance are not represented based on the total percentage known. Although larger known proportions of chemical substances do not have a significant environmental impact, smaller amounts can still entail greater risks when these are classified as hazardous, resulting in that the percentage of represented substances may be misleading. For future investigations, one could therefore investigate the risks associated with each type of represented substance in the T15 unit.

It is considered positive that companies have knowledge and control over which chemical substances that are represented in components used to produce their own products, as this is an important step when striving for sustainability by not exceeding the limited values determined by regulation legislation (Lieder & Rashid, 2016). However, in the perspective of circularity, many challenges do remain in ensuring how chemical substances in finished products should be designed, maintained/prolonged, reused and recycled in such a way that the product

does not affect the environment or human health in a negative way. This, in return, places enormous demands and challenges on companies to have knowledge of chemical substances, technology, legal requirements, and what is required to achieve the requirements to transfer from a linear to a circular business model (Ellen Macarthur Foundation, 2013; Ellen Macarthur Foundation, n.d.). Since knowledge of what chemical substances a product contains is an important part of being able to promote a shift towards a circular economy, this work is thus seen as an important first step for the company to be able to meet potential future legal requirements (DDP and SPI). However, the process of achieving the requirements for circularity is both extensive and challenging. For companies which have already implemented a linear production and consumption model, a transaction towards a more circular business model can result in difficulties when companies lack a standardised system for performance indicators with regards to measuring circular economy. External difficulties such as inefficient recycling opportunities, unclear visions (goals, objectives, targets, and indicators), insufficient laws, and external economic issues could be an explanation for companies' unwillingness to make the necessary investments in the concept. However, companies may also experience internal issues when implementing a circular business model, such as that the implementation requires a major upfront investment with few short-term economic benefits, experiences in technological issues regarding accurate information concerning whether materials / tracking in the supply chain towards recycling is not available, knowledge and skill issues are lacking, management issues in organisational structure, culture and social issues, and market issues (Govindan & Hasanagic, 2018; Kirchherr et al., 2018).

6.2 Recommendations

From this study, it is not possible to draw a conclusion whether the company´s business unit Gasketed Heat Exchangers (GPHE) can achieve total FMD for all products or not, however it can serve as an indication on how status may look like for the mentioned product line.

The methodology applied in this study can be replicated for other products in the company's assortment. For the company to be able to take the last step towards knowing full chemical composition for finished products, the company needs to find an effective and easy to use system for processing information from BOM-lists and suppliers. The company also needs to set an internal goal on what percentage of chemical composition knowledge is acceptable for products produced (e.g., 85%, 90% or 95% FMD?). As an example, Seagate that manufactures storage drives, set an internal goal of achieving 95% total FMD

for their products, with a leeway of 5% for suppliers who could not provide the needed information due to intellectual property or trade secrets (Wu, 2018).

To accelerate the transition towards a more active chemical substance control strategy, and to minimise the administrative work when mapping chemical compositions for future products, the company could use the T15 as a referencing point. Many components used in other GPHE products do most likely resemble components used in the T15. Therefore, by mapping components which are of the same materials referring to the same material standard and/or are delivered by the same supplier, the company can more effectively exclude common components for the investigation, even if the components are produced in different sizes and quantities. After this process is done, the company could investigate the more unique components in respective products, by implementing a method such as the one conducted in this study. This means that the company can generalise the components, and thereby avoid investigating product by product.

To secure understanding and commitment from the company's suppliers, the company could put together a communication strategy that support regular communication with higher management at suppliers. This, with the purpose to promote the ambition/goals of FMD, and the mutual benefits of supporting each other in this important work. The company could also pay extra attention to those suppliers who are transparent and highlight these suppliers as role models that together with the company is working towards setting ambitious goals for their sustainability work. Pointing at what that can be achieved for the greater good through better data quality, transparency, and cooperation could be inspiring for other suppliers. If successful, and if concrete results can be proven, this could also generate mutual benefits in terms of public recognition and brand perception as well as provide an opportunity to attract investors.

Although data from suppliers is seen as necessary for completing FMD, the information gathering does not only depend on the supplier's ability to provide the information needed. It also depends on the ability within the company to create understanding and commitment from employees, and the ability to collect, store, analyse and update the large amount of data and not least to have the capacity to effectively communicate any updates about changes in components.

Lastly, but not least, the company needs to be prepared for that the start of a journey towards FMD in all products and supply chains, will require endurance over time, but also that it requires a significant capital investment goes without saying.

6.3 Method reflection

For this study, the different methods used was the most optimal alternatives to be able to answer the questions at issue, considering time and available resources. By combining an explorative literature review with a specific case study, the author aims to provide the reader with insights into the complexity surrounding chemical declaration through FMD, both from a broader perspective, and by performing an FMD investigation for a product produced by, in this case, an OEM.

As described in chapter 4 "Methodology", the information gathering for the explorative literature review was collected mostly by "grey literature". For the purpose to increase the relevance of a literature review, scientific journals are generally the most relevant sources. Had such sources existed for this topic, it would have added further relevance to the explorative literature review.

In general, a case study does not provide general information about a topic but focuses on a specific investigation within a specific field. Hence the choice of complementing the case study with an explorative literature review.

Although the terms "full material disclosure" and "full material declaration" are considered the same (Assent, 2022b), the author could have used only one of the two terms for both the FMD investigation, and the questionnaire. The two terms have been used separately for the FMD and the questionnaire. However, nothing points to that there is any confusion within the respondents regarding the meaning of either term.

To further expand the relevance of the case study, it could be argued that the author could have compared the GPHE T15 unit with a "different" or more "exotic" model, to see how much these differ when it comes to achieving FMD. Unfortunately, this interesting addition could not be part of this study due to the time limit as they would have required significantly more time. However, the interesting approaches could be a suggested topic for further studies.

7. Conclusion

By combining the method used in this study, and by comparing the results with findings in the explorative literature review, the following conclusions are drawn:

The methodology applied in this study can be replicated for other products in the company's assortment to enhance the knowledge about chemical composition in finished products.

By compiling information though the BOM-list and by analysing the data that has been done in this study and with the help of material standards, one can arrive at a certain FMD percentage for a product. For the investigated product GPHE T15, the percentage added up to 89,1% after using this method. To determine the remaining percentage, the suppliers of respective components were requested to fill out FMD. The FMD request resulted in a 100% response ratio. Out of the respondents, 40% declared FMD for their components. Through this study, the company now has knowledge about 93,2% of all chemical substances in one of their most important products. The BOM-list mapping and analysis together with the answers provided in the FMD investigation, can in combination with the process/system for chemicals of high concern that the company uses, serve as a proof that the company fulfils the second step towards an active strategy (see figure 3). Although only one product has been investigated, the company have with this study also started to cover the third step towards knowing and mapping all chemicals in all products (see figure 3) as the T15 is a standard product, and the components can be found in many other of the products that the company produces.

Aiming to understand why suppliers did not want to declare FMD when asked, they were asked to motivate the decline. The reasons mentioned were:

- Intellectual property
- Trade secrets
- Difficulties in information flow in the supply chain

Furthermore, to get a better understanding of if the company's suppliers see an increased demand for chemical declaration, and to understand what challenges/barriers they experience when asked to declare chemicals in their own products, a questionnaire was sent out to 48 of the company's suppliers. Although the response rate was 31%, the following conclusions can be drawn:

- that a slight majority (eight) of the suppliers answered “no” to the question of whether they see an increased need/demand to declare chemical substances for their products
- among the respondents who answered “yes” to the question, a majority (five) stated that the increase is due to the increasing pressure from authorities and intergovernmental organisations pushing regulation and legislation forward
- that the challenges/barriers suppliers experience if asked to declare chemical information are:
    - difficulties in information flow
    - administration work
    - sharing information which can be intellectual property
    - the complexity of materials
    - if they have a large selection of traded articles (not produced by themselves)
    - that smaller or local suppliers are not able to provide the information if it is not required by law
    - to understand the effect chemicals can have on the environment

Another conclusion is that the result in this study is well in line with what is described in the exploitative literature. The study confirms the difficulties for companies and their suppliers in mapping chemical substances in products and components. The lack of clear and dispersed methods, systems, and complexity in the information chain, make it difficult to achieve the transparency needed to collect data, and the ability to share data with customers.

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10. Appendix

Appendix 1: FMD letter

Dear Valued Supplier to Alfa Laval,

The number of chemical substances circulating the market and used within manufacturing are increasing. Not all known chemicals used in production of goods and products are considered dangerous, but some chemicals have hazardous properties which can cause considerable reversed effects towards humans and the environment. This is driving new and stricter laws and regulations concerning what chemical substances that can be used, and to what extent.

As part of our sustainability ambition, Alfa Laval is now pursuing an initiative to investigate the feasibility of full material disclosure requirements to map and address the issue with chemicals and their presence.

The purpose of this initiative is to create awareness within Alfa Laval and our suppliers, to meet future higher regulatory demands and to promote circularity by enabling recycling, reusability, and not the least to address the human health aspect.

As a first step, we will collect full material disclosures (FMD) from a selected group of our valued suppliers to map the chemical compositions of the articles purchased by Alfa Laval.

Therefore, we kindly ask for your cooperation to provide the needed data for the articles stated on the next page (Appendix 1). All submitted data will be handled with confidentiality and will be used for internal purposes only.

We thank you in advance for your contribution to this important work.

Best Regards,

Alfa Laval Group Sustainability Team

Appendix 1

Item description	**Article number**

Please fill out the table below:
If the chemical substance is represented within an interval, please state what interval.

Substance Name	**CAS Number***	**EC Number****	**Concentration (%)**

** CAS Registry Numbers (often referred as CAS Numbers) are universally used to provide a unique, unmistakable identifier for chemical substances.*

***The European Community number (EC number) is a unique seven-digit identifier that was assigned to substances for regulatory purposes within the European Union by the European Commission.*

Do the above declared chemical composition represent 100% full material disclosure for the specific article? *(mandatory)*

❑ YES

❑ NO

If not, what are the challenges, barriers, or main reasons for not being able to provide a full material declaration? *(voluntary)*

What is, in your opinion, the beneficial effects in contributing to this mapping of chemical components in your products? *(voluntary)*

Appendix 2

Dear Valued Supplier to Alfa Laval,

The number of chemical substances circulating the market and used within manufacturing are increasing. Not all known chemicals used in production of goods and products are considered dangerous, but some chemicals have hazardous properties which can cause considerable reversed effects towards humans and the environment. This is driving new and stricter laws and regulations concerning what chemical substances that can be used, and to what extent.

As part of our sustainability ambition, Alfa Laval is now pursuing an initiative to investigate the feasibility of full material disclosure requirements to map and address the issue with chemicals and their presence.

The purpose of this initiative is to create awareness within Alfa Laval and our suppliers, to meet future higher regulatory demands and to promote circularity by enabling recycling, reusability, and not the least to address the human health aspect.

As a first step, we are selecting a group of our valued suppliers to answer questions concerning chemical declaration.

Therefore, we kindly ask for your cooperation to answer stated questions on the next page (Appendix 1). All submitted answers will be handled with confidentiality.

We thank you in advance for your contribution to this important work.

Best Regards,

Alfa Laval Group Sustainability Team

Questionnaire

Do you see an increased need/demand for chemical declaration for products produced by your company?

❑ YES

❑ NO

If yes, what do you think the increase is due to?

What are, in your opinion, the **beneficial effects** of mapping chemical substances within your own products?

What would, in your opinion, be **the reasons** for sharing this information with costumers?

As of today, is your company able to declare a 100% full material declaration for produced products?

❑ YES

❑ NO

❑ Partly

What are the challenges/barriers when declaring chemical declaration?

How can, in your opinion, your customers support/contribute to the mapping?

If needed, would it be possible to contact you for further discussion?

❑ YES

❑ NO

If you have stated "Yes" to the above question (question 8) please write contact information below. Thank you for your cooperation.

Appendix 3: Letters to suppliers on the questionnaire

Dear Valued Supplier to Alfa Laval, the number of chemical substances circulating the market and used within manufacturing are increasing. Not all known chemicals used in production of goods and products are considered dangerous, but some chemicals have hazardous properties which can cause considerable reversed effects towards humans and the environment. This is driving new and stricter laws and regulations concerning what chemical substances that can be used, and to what extent.

As part of our sustainability ambition, Alfa Laval is now pursuing an initiative to investigate the feasibility of full material declaration requirements to map and address the issue with chemical substances and their presence.

The purpose of this initiative is to create awareness within Alfa Laval and our suppliers, to meet future higher regulatory demands and to promote circularity by enabling recycling, reusability, and not the least to address the human health aspect.

As a first step, we are selecting a group of our valued suppliers to answer questions concerning chemical substance declaration in general. See example of a chemical substance declaration in appendix I to this letter.

Therefore, we kindly ask for your cooperation to answer stated questions via a questionnaire before XX XX, please use the link below (also provided in email). All submitted answers will be handled with confidentiality.

We thank you in advance for your contribution to this important work.

Best Regards, Alfa Laval Group Sustainability Team

Appendix 1

Example of a chemical substance declaration/Full Material Declaration

Item description	Article number
Component X	123456 789

Please fill out the table below:

If the chemical substance is represented within an interval, please state what interval.
Either CAS no or EC no is required.

Substance Name	CAS Number*	EC Number**	Concentration (%)
Carbon black	1333-86-4	215-609-9	5,9
Chromium	7440-47-3		0,1
Sodium hydroxide	1310-73-2	215-185-5	14
Silicon dioxide	14808-60-7		22
Aluminium	91728-14-2		58

** CAS Registry Numbers (often referred as CAS Numbers) are universally used to provide a unique, unmistakable identifier for chemical substances.*
***The European Community number (EC number) is a unique seven-digit identifier that was assigned to substances for regulatory purposes within the European Union by the European Commission.*

Appendix 4

Interviews with Alfa Laval:

1. In your opinion, how important is it for Alfa Laval to receive full material declaration (FMD) from suppliers on chemicals in components used in A L's products?

    a) Not important b) Relatively important c) Very important d) Extremely important

Please elaborate shortly on why.

2. How important, on the same scale, do you think FMD will be to fulfil **future rules and regulations**?

    a) Not important b) Relatively important c) Very important d) Extremely important

3. What do you think the **benefits** respective **disadvantages** could be for a supplier, to provide FMD for their components?

4. What do you think are the main **challenges/barriers** for them?

5. If a supplier is **unable** to disclose this information, what could the potential consequences be?

6. Thinking about the challenges related to providing FMD for **all** Alfa Laval's products, what resources would be needed to comply with future rules and regulations?
    Please be as specific as possible, taking the whole sustainability chain into consideration. Many examples can be relevant, for example personnel with the right knowledge, legal resources, economical resources, phasing out/in products, time to market, development resources, finding new suppliers.

7. How long time do you estimate that A L would need to get systems and processes in place to in a systematic way be able to collect and present data, related to full material declaration of chemicals in all products?