Master's Project (ACFA7003)
Dissertation

"The role of emerging advanced technologies in facilitating the remanufacture and upgrade of end-of-use electro-mechanical and mechanical equipment, tooling and assets. How successfully are these emerging advanced technologies contributing to the adoption of advanced methods of remanufacturing."

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Abstract.

With the accepted need for a sustainable approach to manufacture with consideration for increasingly limited natural resources, the application of '*remanufacture*' is becoming an increasingly important route for end-of-life whole vehicles, assemblies, tools, or materials. We can define the term in many ways but 'remanufacture' can be usefully described as *'a process of returning a used product back to at least as-new condition'* (Scottish Institute for Manufacturing), and Ijomah et al, 2005 gives us a good basis for consideration of the process (Appendix 15).

If we couple this increasing scrutiny on resource use to the spreading digitisation within manufacturing, following advanced technology advancing control, automation and data handling methods, then we would seem to have two potentially divergent themes, sustainable use of resource against the rising cost, resource and energy demands of the new technologies, techniques and approaches. Costs could indeed increasingly outstrip any advances we can make in the already successful re-use of materials by remanufacture.

This research will undertake a literature review to set out some current themes in remanufacture, and current thinking within remanufacture as advanced manufacturing techniques and advances are improving efficiency in the traditional remanufacture processes. Having defined the current situation, the research will then extend into a critical view of comparative paths of improvement of remanufacture, or otherwise, in adopting the advanced manufacturing techniques.

The themes of carbon reduction and energy efficiency within manufacturing are likely to impact on future business thinking on advanced manufacturing methods – but can degrees of adoption be raised by easing the barriers to re-manufacture, increasing the sustainability of advanced manufacturing technology advances from introduction to wider take-up within any business? A review will be made on the effects of common global and UK Government support and how this might promote - or deter – re-manufacture using advanced manufacturing across the UK.

To research the current reman uptake across manufacturers and professionals in industry, I engaged in some primary research to seek their views, take-up of reman and advanced technologies, and their wider opinions on remanufacturing. This was informative and pivotal

to my full understanding of the impact – or otherwise – of advanced technology on the take-up of reman across industry.

A view will be taken on how business models are changing due to emerging remanufacture opportunities and will need to evolve further as reman develops to match new capabilities becoming available to reman practitioners. Processes are emerging that may be financially viable, or acceptable viable in resource or other considerations, due to the introduction of advanced manufacturing technologies.

"Progress is impossible without change, and those who cannot change their minds can change nothing" ***Ref: George Bernard Shaw 1944***

Contents.

List of Abbreviations and Terms used.

AI, Artificial Intelligence

AM, Additive Manufacturing

AR, Augmented Reality

Bol, Beginning of Life

CE, Circular Economy

EoL, End of Life

FMCG, Fast Moving Consumer Goods

HDOR, Heavy Duty Off-Road

NICER: UKRI National Interdisciplinary Circular Economy Research programme

OEM, Original Equipment Manufacturer

RFID, Radio Frequency Identification

RLES, Resource Life Extending Strategies

RUL: Reliable useful life

APRA Automotive Parts Remanufacturers Association

CORE A used part, often an engine or other major assembly, intended for reman

CPPS Cyber physical production systems

FPV First Person View, describing drone technology

HCME Hitachi Construction Machinery Europe

HDOR Heavy-Duty and Off-Road equipment

ICT information and communication technologies

OER Original Equipment Remanufacturer

PLA Peoples Liberation Army (of China)

REMAN The process of remanufacture

REMAN INTENSITY THE ratio of remanufacturing to new manufacturing

RLES Resource Life Extending Strategies

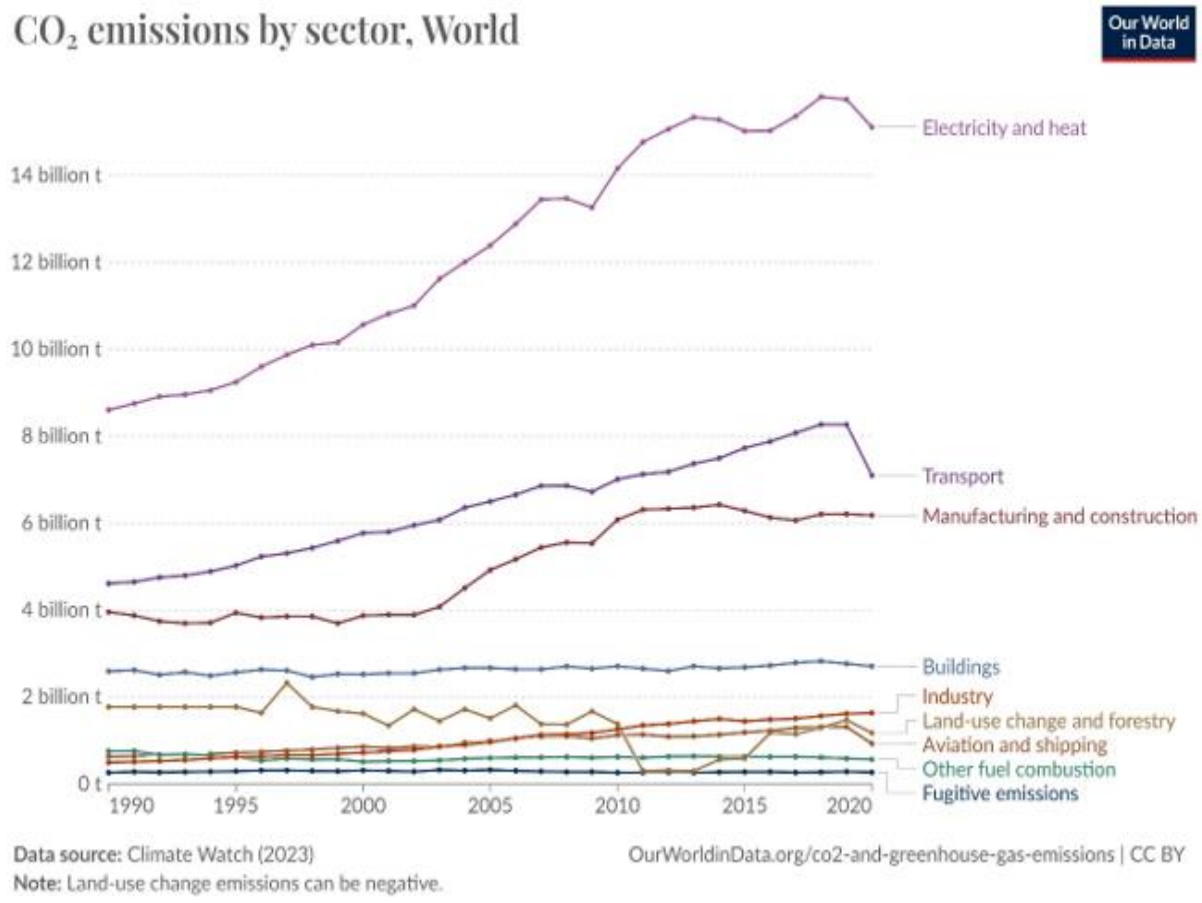
RUL Reliable useful life

VSM Value Stream Mapping

1.0 INTRODUCTION

1.1 Introduction

The Bruntland Report of 1987 by Gro Harlem Bruntland, then Prime Minister of Norway (Bruntland, 1987) made it plain that environmental protection was the only way to long term sustainability across the Globe. This was followed by the pivotal 1992 Rio Earth Summit (UN 1992) and the famous 'Rio Declaration' outlining 27 points to drive sustainability across the globe. The urgent need to address carbon emissions and uphold the statement of the Rio Declaration has driven the global green movement, and the drive for sustainability in our activities. Amongst this, manufacturing and construction accounts for the third highest source of carbon emissions across industry sectors (**Ritchie et al, (2020), Appendix 1):**



As a result, the global drive for a circular and sustainable economy, to replace the current 'take-and-waste' economy is at the centre of the search to make manufacturing as sustainable as possible**.**

With the potential of all of the '10R' standpoints of sustainable manufacturing (Bag 2021), there is a particular opportunity for remanufacturing to dominate the sustainable manufacturing field. The discipline of applying newly formulated technological methods made possible by recent data and computational advances to perform inspection, computational analysis, strengthening, repair, coating, hardening or any other form of treatment to end of life items opens up a new world of technological solutions at lower cost and carbon footprint.

There are a wide range of definitions of 'remanufacturing' (which we will refer to in this work as 'reman'), which mostly agree on the main themes, but vary widely on the content and extent of what reman should be defined as. To rationalise this, we will paraphrase the definition used by a Winfred Ijomah in 2002, the term 'Remanufacturing' covers taking a used and currently unserviceable product or assembly, disassembling it to its constituent parts or sub-assemblies, and then by applying engineering and manufacturing methods, returning that product or assembly to a new condition, crucially with an 'as-new' warranty to accompany it (Ref: Ijomah, 2002). The basic process is to disassemble, inspect, replace any wear parts or failed elements, but crucially to return the cutting edges, dimensional status, and engineering function, to a new condition, often with upgrades provided with current versions of that assembly. The assembly is then re-assembled, evaluated and warranted for re-incorporation into its function as a reman assembly item.

The reman process is not new, with attempts being made from the middle of the 20th century to establish remanufacturing as a necessary process, following the huge levels of production brought about by the Second World War, which left resources depleted and funds for new products extremely limited. In Lunds study of American remanufacturing in 1984 (Ref: Lund, 1984), he covered the rise of reman in American industry, and where this might assist developing countries in establishing their economies, both in obtaining tools for manufacturing items, and in reman of those tools needed to produce them at lower cost than new. His early look at the potential benefits in reman in two contracting economic situations does have resonance today, and to my study here, for two important reasons.

Firstly, the increasing scarcity of raw resources for new production reinforces the need for retaining the embodied resources already within existing assemblies. Secondly, there should be unlimited potential for the development of advanced technology to improve the reman

process by making techniques that have so far been uneconomic, or simply not yet thought of, until the need arises. To what extent this is being realised, and what stands in the way of these crucial advanced technologies becoming commonplace in the reman process, is the focus of my dissertation study.

The economic reasons for advancing reman are many, less energy is needed in producing an equivalent product, and the embodied materials are retained (Lund, 1984), indeed the potential for higher profits exists where the reman process translates into the sale of a reman item, even when discounted against newly manufactured items, due to the much-reduced cost base to produce a warranted reman item.

The environmental reasons for reman are also many, from the reduction of materials to landfill, to the lower resources, both real and in energy terms, needed for a reman item. The justifiably deeply embedded environmental legislation now in place can only increase in coverage and intensity, and the opportunity for advanced technology to grow reman in this context should allow industry to both meet legislation and operate profitably into the future (Webster, 2007).

1.2 Aims and Objectives

My aim was to focus on where reman is being used in manufacturing, is the development of advanced technology facilitating the reman processes, or are there significant barriers that are limiting the broader take-up of reman in current manufacturing. Are the advances possible from advanced technology reaching the areas needed for reman to be a mainstream manufacturing discipline across industry as a whole. My objective was to seek a view of the current incorporation of recently developed advanced technologies, identify where blocks and risks may be restricting reman, and if possible define some potential areas for action to ensure a wider take-up of the important and productive opportunity that reman represents to provide a sustainable future for manufacturing.

1.3 Background and Justification

As an engineer I have been designing innovative technical solutions throughout my career, in sectors ranging from soil mechanics and alternative concrete structures to the complexities of anaerobic digestion of organic wastes. My frustration has been that, using the most advanced design tools of the moment, such as finite element analysis, it had been possible to

identify the stresses present in a structure, but short of a complex and expensive third-party design, there was no capability to design, as I had to, a glass reinforced plastic, sectional, composite dome structure with access loading and mounted sensing equipment. This design was performed by hand calculation applying basic engineering principles of beam bending theory in the composite design. This was successful in producing a workable and safe sectional dome roof that is gas tight and fully in service today. As a consultant now engaged in assessing current research and development across a variety of business sectors, it is becoming clear that new design tools and computational capability emerging under the heading of 'Industry 4.0' can now be applied to complex design and analysis, giving design capability at a whole new level. The onset of AI within this process has the additional capability to rapidly advance this design and analysis, enhancing resource efficiency, the end result being only limited by the ability of the designer to formulate the problem, and the regulatory acceptance to regulate, and eventually allow, these new design approaches, such as AI generative design.
One of the main drivers for me to start this course was the mindset and commitment to sustainable development I had developed from designing very efficient soil and concrete composite structures to the generation of renewable energy from anaerobic digestion. The principles of remanufacture demonstrate a significant opportunity to progress towards a circular economy, and the examination of the limitations, barriers, and capability of reman are my reasons for choosing this as the subject of my Dissertation.

1.4 Methodology

I will commence with a literature review, approached from the standpoint of providing a view on the development in reman thinking, and the current role of remanufacturing within industry, whether using examples from within the UK, Europe, or the wider global economy. This has been undertaken over the limited timescale of the early 90's to the present day, late 2024, to draw on examples for the purposes of a literature review. The wider report uses and references articles from a wider timescale, as is appropriate to illustrate the influences on development of, and barriers to, reman to date.

1.5 Research ethics

Any direct communications that have been the basis of comment and publication within this report have been cleared for my use by the relevant correspondent, who has been

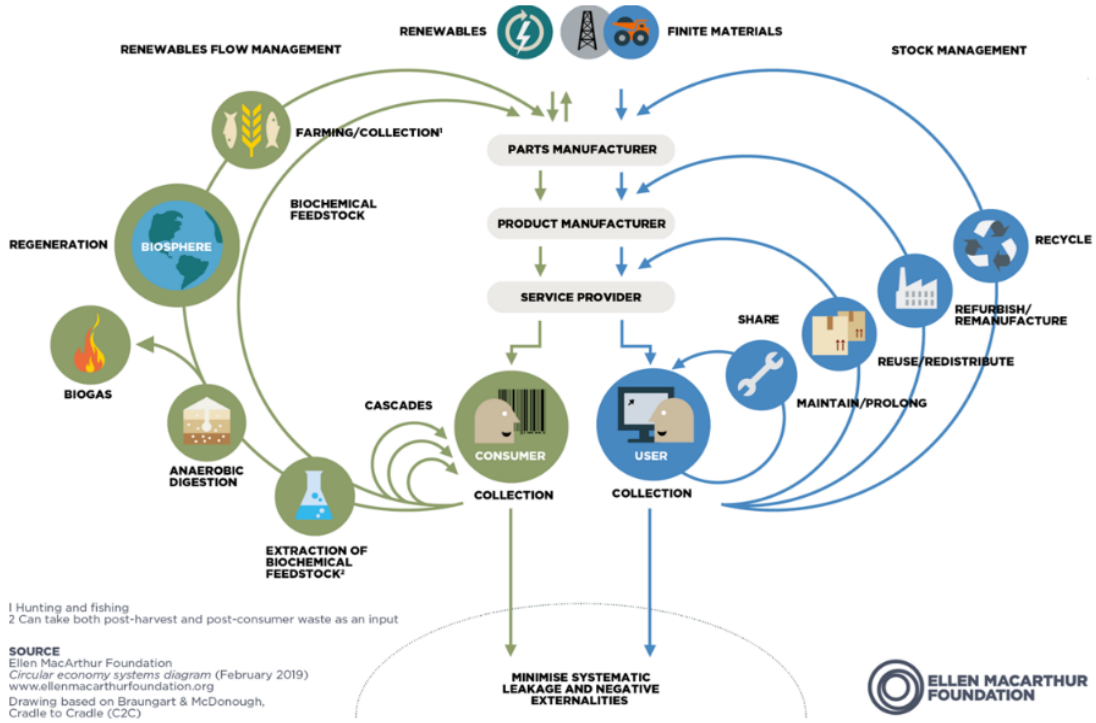
acknowledged as such, or are taken from my taught MSc. course content. There are no issues of confidentiality or intellectual property within the discussions with respondents in my primary research interviews. There are no other direct ethical considerations as all of the of references within this report are published and available through open-source academic channels and are acknowledged and referenced as others' work. However, the consideration, combination and questioning of these references is my own.

2.0 CURRENT SITUATION FOR REMANUFACTURE

2.1 Literature Review – recent advances and current status within remanufacture in 2024

The purpose of this literature review is to briefly assess the progress of remanufacture into consideration within the developed economies up to the present day – this will demonstrate the emergence of themes within remanufacture and its overseeing commercial applications. By limiting this to a recent timescale – between the 1960's and today - we hope to demonstrate the advances now being made and some of the barriers and limitations recognised, , which can be later examined.

As far back as 1993, Coates (Coates, 1993) recognised that a circular economy would have to be developed, actively against the intransigence of the current place-sitters in high volume manufacture. Although he was writing from a US perspective, he accurately predicted that two legislative changes would be needed to precipitate interest in resource re-use, firstly a ruling that automobiles would have to return to OEM for disposal, and secondly, an act detailing limitation of the proliferation of non-recyclable plastics and polymers. There are now legislations on both these areas in Europe and the UK, with the UK Government placing the control of EOL vehicles and their dismantling. Blomsma (2017) demonstrates the importance of the circular economy with a useful overview of the range of resource management



Ellen MacArthur Foundation –' Butterfly' Diagram (Appendix 13).

framework over time (Appendix 2), from think-tank s such as Ellen MacArthur Foundation (Butterfly Diagram, Appendix 13, above) , to those generated by business, including Ricoh and Novelis. Most of these include remanufacture to a significant degree. Notably, the Waste Management framework (2015) indicates a cycle that is not circular, implying that it is not in their interests for everything becomes reusable. Blomsma firstly concentrates on the resource life-extending strategies (RLES), and then usefully separates the developing waste and resources and circular economy (CE) debate into some formative periods:

1960-1985 – Preamble period – emerging waste handling, and 'end of life' (EOL) strategies, realising that landfill was finite and costs of incineration were becoming prohibitive.

1985-2013 – Excitement period – waste being a positive force, and the extension of use and some re-manufacturing strategies emerged, including, importantly, remanufacturing.

2013- present day – Validity period – the CE concept is taken on in increasing breadth within business and legislative bodies. However, the interpretations of circularity are diverse and appear to be preventing direct comparison and understanding of the circularity assessments. An example is the EU 2015 which concentrates on low grade recycling, failing to take the opportunity and include remanufacture as a building block of the new CE.

Bras in 1999 recognised that, even at this date, as a discipline the resource dedicated to reman was less than that to pure recycling, refurbishment and repair. Bras outlines the contemporary types of work in the field, and was intended to be a jumping off point for those wishing to make a start in the reman journey as an academic researcher, or perhaps an operational manufacturer.

Telukdarie in 2018 showed the increase in digital capability has forced business which deal internationally to amend maintain competitiveness on a wider, global market reach. To a certain extent this directs the agglomeration highlighting lesser competitive businesses into larger combined bodies. The issues may well be more complex and include insufficient analysis of cost and operational data leading to poor decision making and lack of direction as

to better practice and lower costs, generating a stagnating mindset and resistance to introduction of newer technologies as too risky.

Dickson, in McKinsey/Ellen Arthur Foundation 2019 begins by confirming that the industrial economy must rapidly change if it is to maintain development and not be overwhelmed by negative environmental and social impacts. The full impact of a circular economy could have driven a new benefit of 1.8 trillion Euros by 2030 (E McA F 2023) at the same time keeping abreast of resource challenges, creating innovation, and creating environmental benefit. There seems little evidence this has been achieved, even in part. McKinsey here gives us a concept where AI can accelerate this transition within our context of remanufacture by improving the industrial processes to sort and disassemble, remanufacture components using advanced technological methods and close the loop by closing off large sections of the 'end of life' of the current linear product cycle. McKinsey/ Ellen Arthur Foundation 2019 does show us how a circular business model of remanufacturing is advanced by AI prediction of fluctuating supply and demand of used product and by enhanced study of the parts condition and suitability for remanufacture. Only with the ability to collect and collate huge amounts of data, and the advanced AI and other analytical tools to unravel it, does this decision-making become feasible. McKinsey also outlines the AI selection of units for remanufacture before any failure which would bring them out of use and disrupt production, and the selection of core units for remanufacture by scanning for dimensional compliance and faults.

Gunasekara in 2020 shows that reman seems limited to few advanced economies, and in his case of Sri Lanka that barriers exist preventing advance of reman there, where rapid social development is driving rapid expansion of car use. This makes reman essential to keep advance of the tough environmental restrictions on polluting vehicles, as reman uses far less energy and releases the embodied value and materials already in the parts that would otherwise be lost, all vital in that type of economy. Thinking of wider economies, Gunasekera identifies barriers to reman do exist within industry, which could be addressed with advanced technologies. However, he points out that more important are barriers within academic and crucially, governmental and policy barriers that need to be addressed first – the reman can be done, but will it be allowed to be done, and backed by sound research that enables its safe application.

Encouragingly, Su in 2020 outlines the importance of reman within aerospace due to the large cost savings involved. They outline the difficulties of assessment of reman necessary to deformed aero engine compressor blades. A new analysis model was illustrated using emerging advanced computational methods to interpret the blade scans, allowing more precise dimensional assessment possible, and identify the precise reman operations necessary for each blade – this was simply not possible before these combinations of analytical and computational data. That the aerospace industry can use and develop accepted methods of reman in such safety critical applications demonstrates that institutional, safety body, and overall policy barriers can be overcome with reman assisted by the verifiable advanced technology. The current restrictions on Generative AI within the aeronautical industry (Ref: Gillen,2023) is an example of current safety body restrictions to AI which will have to be overcome before Generative AI can be used for reman, or any other operation, within aerospace safety.

Demonstrating the importance of data gathering and computational advances in reman, Maio at al in 2020 put forward developments in advanced analytical methods for assisting remanufacture of a hydraulic support column. By software optimization of the process the re-coating thickness necessary could be thinner and the reman assembly temperature reduced, resulting in lower energy and stresses during assembly of the reman column. The real advance in reman will be to demonstrate by what extent these computational advances reach the reman factory floor via the management and operational teams.

In 2021 Zhao et al showed the improvements possible in assessment of the fatigue stress levels in excavator jib beams. By using advanced data sets derived from combining newly developed computational analysis methods with traditional FEA, complex fatigue stresses and stress history in service and in remanufacture can be analysed for the first time. The team showed how this integrated fatigue model could better estimate the remaining service life in reman excavator beams, allowing a safer and more reliable operating future for the reman item. Reman in heavy machinery assemblies has a long history in engine core assemblies (See section 3.3) this demonstrates that larger critical safety elements such as the main jib beams can come within dependable and practical remanufacture, and wear/failure prediction.

To illustrate that metallurgical depositional methods in reman are made possible due to advancing technology, Ren et al in 2021 showed that a Titanium/Aluminium/Vanadium alloy coating necessary as part of a reman process could be improved in hardness and durability by an optimized pulse laser remanufacture process, with laser cladding followed by laser shocking. This process was shown to enhance the friction and wear coefficients and increase the microhardness of the deposited layer. It is notable that the funding and facilities for this research was from the Chinese Fund of National Defence Science, a theme found commonly within the reman references seen and studied, which included extensive US Government funded reman of defence equipment in all military sectors. It cannot be underestimated how much of a driver the defence applications are to the ongoing implementation of reman across the global manufacturing industry.

Bag in 2021 draws on the many circular economy models, including the Ellen MacArthur Foundation (Ref Ellen Mac various), to show any worn item or assembly passes through a combination of the 10R processes, namely Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover. The introduction of advanced technology of manufacture brings the items through the process of interest, remanufacture, and the capability of the advanced technology and its successful application is a marker of success of the technology and adoption of the remanufacture process, progressing towards the desired circular economy. Bags findings point out that the degree of adoption of advanced technology and associated 10 R advanced manufacturing capabilities are statistically significant, advanced manufacturing capabilities are having a positive influence on sustainable development outcomes, and that businesses with high degree of advanced manufacturing implementation lead to higher level of 10R capabilities.

Bailey, 2022 shows us that commercial companies considering their future manufacturing relevance and competitiveness must recognise that we must roll back development from the ‘take to waste’ cycle and replace that with a circular economy based on a full life cycle understanding of the products needed and produced – from linear to circular. The silo working we all see in our organisations and commercial relationships which relies heavily on past knowledge, only perpetuates the linear mindset and continues the waste. In this we can easily see that the waste industries themselves are a considerable fraction of industry

turnover, and their continuance and profit levels depend on the wastefulness of the current linear mindset. Bailey reminds us of the circular representations of the economy presented by the Ellen MacArthur Foundation (Appendix 13) which includes the remanufacture as a significant workstream. Bailey goes on to present where the resource-heavy Celsa present themselves as an industry and a company at the forefront of the circular economy taking those elements of ferrous and speciality metals that are end of life and removed from continuing use in the product, and then recycle those into new raw steel for use in production. This is not new, the reuse of metallic products has been in practice since metals were first smelted, but at least the mindset is there to draw the industry into the circular economy principles drawn out in BSi 2017 (Ref BSi 2017, the British Standard covering Circular Economy Principles.

We can illustrate where previously unavailable advanced technologies have enabled reman to take a fuller position in resource recovery for manufacturing. Dance (Dance,2023) sets out in a very recent article in 'Nature', November 2023 that rare earth metals are being refined from substrates by treating them with engineered bacteria. This 'biomining' to release rare earth metals separates the elemental metals essential for the some metallurgical remanufacture processes, including wearing surface reman of worn machine tools, using advanced manufacture methods including metal deposition and polishing, and laser shocking, referred to elsewhere (Section 3.5) within this report.

The high quality and integrity reman process followed by Caterpillar, Volvo, Hitachi and other high quality manufacturers of critical equipment bears no resemblance to the 'under the arches' current perception of remanufacture held in most quarters (Caterpillar, 2008) this image pertains more to the refurbish and reclaim headings, where the process undertaken and the finished item is in no way as good, or better, than the original as reman items are claimed, and proven by results in service and new warranty.

2.2 Recycling, Repairing, Re–using, Remanufacturing – which path to follow

Bag 2021 set out the framework of processes previously outlined in all of the circular economy models, such as Ellen MacArthur Foundation (Ellen Mac, various). There is a hierarchy of '10R processes', namely Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture,

Repurpose, Recycle, and Recover. With the onset of advanced manufacturing technology, the degree of reman application is a marker of success of the technology and the adoption of the process, gently moving towards the desired circular economy.

The direction of travel must be that the discipline of reman is – intuitively - far more involved and exciting than all of the other '9R's', as the techniques to reman are of more profound and technical nature than the remaining 9, which are, to a greater or lesser extent, already established in practice. Clearly the greater the exposure of businesses to advanced manufacturing the more capable they will become with the reman process and procedures, and the depth of possibility the new technologies exhibit. The existing '9R's will remain to operate, with the reman '10thR' becoming the weapon of choice of the enlightened and smart businesses and manufacturers.

3.0 CURRENT SITUATION FOR REMANUFACTURE

3.1 Reasons and rationales for remanufacture

As one of the '10R's referred to by Bag, and others, reman has been studied by academics extensively, as I have attempted to bring out in my literature review. In the real world of competitive manufacturing business, however, with its real limits to ready markets and relevant training, and the difficulty of affording the investment in new technology , the opportunity to consider any item or core for remanufacturing has to be within the horizon of the business, or it will never be considered in favour of 'business-as-usual', and nothing will progress or change. I will attempt to demonstrate the reasoning behind the reman that is occurring across a broad but selective industry manufacturing sectors. There are particularly good reasons why the reman is performed in certain sectors, and why it is not in others.

3.2 The 'Core' principle

The reman option counters the three normal options available to a plant or equipment owner with a mechanical issue or end of life problem. These three options break down into purchasing an expensive new part and have machine out of service whilst this is replaced, he can scrap the whole machine and buy new, not an option under many years of service, or take the critical machine to an unaffiliated dealer to repair, with no OEM testing or guarantee. The reman unit, however, can be supplied to the customer at affordable cost, without interruption of service, on direct return of his own end of life or unserviceable plant unit. The customers own returned unit – or 'core' – is then the raw material for the reman process, eventually producing another reman item with new guarantee, and importantly necessary hardware, software and data connection protocols that come with the currently supplied plant unit as new. The 'core' can be a full heavy plant item, or a simple engine block, or an individual assembly or sub-assembly from a vehicle or plant model. The common theme is that a 'core' is an identifiable OEM unit that can be dismantled, inspected, cleaned, remedied in a wide variety of manufacturing methods, and then re-assembled, tested, and warranted as a 'new, but remanufactured' item.

For a useful demonstration of the principle of a 'core' of equipment, CoreCentric Solutions (EmcF 2021) acts as both a large repair programme, and a redistribution network for reman goods it brings through its processing. A widespread customer frustration has been fuelled by the current

'take-and-throw-away' linear economy, where consumers have seen a reduction in repair solutions as product design and manufacture cycles become shorter. This results in a larger selection of current product range for OEM's and factors to stock and make available the necessary spares and service items, which becomes financially unsupportable. The options have narrowed for some consumers to dispose of the defective item and buy new. Many high-value and minimally defective items are therefore scrapped, where the fault remedy may be simple but is unsupported. – the diametric opposite of the direction towards a truly circular economy.

CoreCentric capture the value in returned and defective products and items – collaborating with large retailers on their 'returned products' streams and FMCG manufacturers to operate repair programmes that the companies themselves do not wish to perform. The reman products are then redistributed back to the consumer or market. This is creating several parallel but new markets in these reman products, whilst directly countering the single use and disposal of salvageable products, the mass of these created markets allows the volume to attain beneficial ROI in the proposal. The CoreCentric model claims over 1M service parts and 400K products diverted from landfill annually and saving 85% of material and energy necessary to make the equivalent new product.

3.3 Heavy plant equipment remanufacture

The sector of heavy plant demonstrates the largest volume of a specialist material within an assembly – such as full engine, gearbox, main jib or mast- where the smallest elements of tolerable 'wear' from constant operation can render the whole unit inoperable, to use the military term 'unserviceable.' This is despite the worn elements, faces or bores, being tiny in proportion to the unit overall weights, and importantly, cost. The embodied value within the heavy plant unit is still considerable, but the unit is no longer able to perform reliably and needs overall replacement, or significant work. In addition, significant 'fatigue' considerations also apply where developing and locked-in stresses are present in the main unit, which will need to be checked for, issues located and remedied as part of bringing the unit back into use. Thus, when the extreme imbalance between high capital unit cost and the embodied value in the unit is set against the minute areas of wear that need to be replaced or remanufactured, the customer has a straightforward decision to make. He will recognise far higher return on investment from a lower cost replacement reman unit, using his own unit as an exchange

'core,' than he would from a hugely costly new replacement, with little return arising from his 'scrap' item. The heavy truck reman industry demonstrates this across the major sector manufacturers, including Hitachi, Caterpillar, Komatsu, Terex, and Volvo.

Hitachi reman centres in Japan and Zambia – Lusaka – deal with enormous African and European markets excavators, loaders, and dump trucks, where exceptionally high mechanical wear and high ambient operating temperatures demand highest standard, warranted, and affordable reman, justifiable in business case terms for these high-reliability machines. Hitachi provides reman of over 200 main parts and 'cores', including those wear parts for the largest Hitachi site equipment, earthmoving and mining plant, essential in construction and raw material extraction.

Reman ensures quality, full disassembly, and inspection to OEM standards and advanced tech methods. Gaskets, wear parts, seals, are all removed and replaced with new – these processes will only ever be improved by automation by robot as non-critical disassembly. Full updates on software and mechanical improvements and upgrades on materials are incorporated – the reman product is improvement on the original OEM product, rather than merely a clean-up and polish perceived by reman sceptics. Testing to OEM standards is rigorously performed to ensure a warranty of 'as-new' can be given – clearly refurbishments and non-OEM workshops working on upgrades and part replacements are unable to do. Komatsu in their turn had a reman plant in Mandalay, its first in Myanmar, to produce generators and remanufacture components as far back as 2015.

Kojima, 2017, points out that heavy plant remanufacture was not only widespread at his date of writing, but that trade restrictions on importing remanufactured goods could be, and were being eased, in particular in areas undergoing earlier stages of industrialization. The key is the awareness of the value of remanufacturing for cost reduction in developing and development industries within these industrializing zones. In my view, a sensible extension of this would be that advancing the level of technology within these industrializing regions will promote the acceptance of reman overall, as well as broadening the engineering possibilities for remanufacture in those industrializing zones.

Ghomghaleh in 2020 showed that advanced systems analysis was improving the predictability of heavy plant critical equipment on a Komatsu excavator to enable more estimation of

reliable useful life (RUL). In this case better data analysis was giving more reliable warning to withdraw units for maintenance and eventually, remanufacture of critical wear parts. In this case, the criticality is more refined, due to the external imposition of trade sanctions restricting the access of the mine- located in Iran - to new or replacement parts.

In the case of Volvo, who have a well-established heavy plant reman programme, the

symbiotic relationship between dealers and Volvo as OEM is crucial to ensure reliable data on core units coming in for reman and assess the timescale for reman unit to replace it to be available for the customer to exchange for his unserviceable core unit. Cores consist of the engine, main transmission units, battery packs, diesel particulate filters, and major electrical components - the cores go back to Volvo's 'Core Hub' – effectively a swap, essential to maintain productivity on such high value capital items. Within this process reman has become an accepted source of reclaim for rare earth element materials including platinum and other rare earth metals incorporated within battery units. The reman process does not need to release these elements but are re-incorporated into reman units with minimal reprocessing. This is the lowest cost reclamation method for these rare earth metal elements within a circular economy.

The reliable availability of a core is essential to the flow of reman work, the core becomes the 'raw material,' stripped down to a starting point that becomes an 'as- new' unit with new core registration number, updated capabilities, and, importantly, a new warranty guarantee.

All of the processes of reman, starting from dismantling and cleaning, will demonstrate process improvement from the introduction of advanced technology into this established process. Blast cleaning with soda and de-greasing, followed by detailed ultrasonics and X-ray for crack testing highlights core units that cannot proceed - salvage of core components is remarkably high, 85%, and wastage to go to material recycling exceptionally low. Reman in Volvo has decades of practice and readily accepts the incorporation of modern technologies, and crucially realizing a demonstrable 80% of energy saving on manufacture from new. The issue of de-skilling and replacement of roles by automation is countered, as Volvo demonstrates skillsets are preserved and maintained in themselves as the OEM and are augmented as the volume of work expands in reman, with robotics taking the required skill levels in an upward trajectory, supported by training, and upskilling as required. Skilled staff

are also re-skilled on older OEM technologies they encounter in the reman process, where they would previously not have been trained, as no purpose existed for them to do so. .

As one would expect, wear and abrasion and pure mechanical stress are the highest in service of plant at this scale and the size of machines and criticality of an unplanned outage due to failure is highly cost critical. The planned maintenance is a crucial part of the heavy duty off-road (HDOR) machines lifecycle, and the normal accepted process is for the business owner HCME to take in a plant, or part, and to bring away a reman machine, or part, exchanging the machine or part for the worn, or even failed, 'core' unit. Advanced technology is taking an increasing role in driving this capability and criticality within Hitachi.

3.4 Automotive equipment remanufacture

The Automotive Parts Remanufacturers Association (APRA) have indicated in recent reports that they consider the global remanufacturing industry will double by 2030, whilst the EV section of the industry stated to be the key catalyst of this growth. It is useful to consider where the key constituents of the EV might grow the reman sector - namely battery reman, motor reman, electronic component reman, and EV charger reman. The importance of scarce battery resources drives the demand for circularity in this element of the EV build. All of the manufacturing and disposal stages of EV batteries are under intense scrutiny – and rightly so – so the approach the proper reman of these batteries must take a priority as the volume of the existing, and future growth trends , in EV's, both demands.

The reman industry is well established in the electric motor sector – one of my primary research correspondents (Electric Classic Cars) is a remanufacturer of classic ICE vehicles into electric motor-driven classics. The modification of used electric motors is crucial to their operation. Again, the motors are resource and capital-heavy and reman can and will continue to make a large impact on drive motor production. The sophisticated electronics in electric vehicles can be difficult to replace and remanufacturing them will become more cost-effective and sustainable than manufacturing new. This gives the opportunity for electronic components to be swapped out, and new units fitted, improving the performance of the EV. Chargers are a critical area of the EV infrastructure – the reman discipline can reduce the costs of producing new chargers and extend the life of these components at EOL.

In the present day, the recent article focussing on reman by the Ellen MacArthur foundation (Ellen Mac 2024) demonstrates first-hand evidence from OEM companies at their Foundation CE100 meetings showing that businesses promoting and practicing reman on items are not disadvantaged by loss of new product sales. The reverse is true, in that companies embracing reman find that it not only becomes a recognised cost-centre of their business, but a profitable one also. As a further potent demonstrator of the business confidence in reman and the wider aspects of circularity in the automative industry, in 2023 the financial services company Stellantis created SUSTAINera to offer individuals and professionals a solution for the take-back and recycling of end-of-life vehicles. The service was launched online early January 2024 (www.valorauto.com). (Stellantis 2024) The venture also covers a future venture for recycling of electric vehicle batteries in Europe and North America. To show the growing appetite for reused parts, Stellantis reports that its sustainable parts division showed an overall rise of 18% in activity, with 83% rise in reused items. They note a 15% of all customers aftermarket sales are now being served by sustainable parts, either reman, reused or recycled.

A previous industry correspondent , Richard Morgan and Jon Peck from Electric Classic Cars, use reman and used equipment in their classic car remanufacture. In their case they are remanufacturing the whole vehicle to incorporate the items needed by the EV battery, drive/s, and complex wiring looms and cooling systems, from a personal communication, March 2024

In all cases where salvaged Tesla motors are used, they are fully refurbished, completely stripped down, all seals and bearings are replaced, and the main differential is removed in favour of a limited slip differential. There are gearing changes necessary, in the case of the Defenders a custom gearing which ECC have developed themselves alongside a local gear manufacturer. For Defenders the large rear drive unit is used, Minis use the small front drive unit, and Porsches use either the large rear or small rear depending on customer needs.
As the motors are fully ‘remanufactured’ by ECC they have ECC one year warranty, as do the ECC custom battery packs.

3.5 Machine tool, die and mould remanufacture

Due to the precision nature of machine tooling, tolerances in the tool, due to wear and abrasion changes to the tool during repeated operation, are vital to the final machined products dimensional and tolerance requirements. Thus, the stability of the tooling surfaces, the harness and durability of the wearing surface background, and the overall rotational balance and stability of the machine tool are essential to its operation and effectiveness. Traditional remaking or regular re-tooling would involve either a completely new toolset, or the machining and re-casting of new wearing surfaces. If advanced manufacturing is going to improve this process by then it must be by reducing the volume of tooling assemblies that go beyond traditional 're-tooling' and have to be recycled back to base metal, reduce the degree of work to remodel the machine tool, and improve the overall methods of assessing the rework required in reman, and in remaking the wearing surfaces.

Purely resurfacing the wearing surfaces is the traditional method of refurbishment – leaving the possibility that undetected faults and fatigue within the tooling base metal will cause an unexpected tool failure with consequent damage to surrounding equipment, danger to operatives, and extended period of clearing up and installing, balancing and evaluating a replacement, new, toolset. with advanced technology the opportunity now exists to assess the toolset for surface dimensional stability and wear, with laser scanning and modelling, and internal fatigue, cracking or embrittlement using AI- assisted Xray and other non-destructive testing. Time needed for these scanning operations, and the ability to use AI to educate the system to be taught, and self-learn, common and unexpected failure modes in the base material, in cutting surfaces, and any interfaces between hardened and main body base metal within the tools.

Dies and moulds are used as essential tools for the manufacture of engineered products, and are themselves subject to wear, failure and the obsolescence of the items being manufactured from them. Due to the aggressive conditions of use, and the high-grade materials used for dies and moulage, the necessity for economic replacement is more acute that for most engineering parts and assemblies – as far ago as 2006 80% of the moulds in automotive components underwent either repair or reman. (Chen reported in 2014, after Pecas, 2006). Lavtar in 2011 (Lavtar, 2011) pointed out the main failure's modes of dies, and raised the opinion that a die manufacturing engineers main task is the prediction of die life

and the prolongation of this by whatever means available. Costs for dies comprised 15% of products cost, however, an unplanned die failure raised production costs by 30%. The criticality of finding wider means to ensure longer die life is obvious to the writer. Chan identifies that dies performing distinct functions exhibit differing failure modes, including (mostly) wear, but including additional combinations of plastic deformation, thermal cracking and fatigue cracking. The development of improved technologies should clearly, be broad enough to allow all die tool functions to be improved. At this time Chan recognised that reman was in its infancy in dies and mould, and correctly identified that the push for sustainability would require, and drive, the incorporation of emerging advanced technologies, especially in automation, residual life evaluation, and design for reman. For examples of the use of these advanced technologies, in the literature review that Ren in 2021 was already showing Titanium/Aluminium/Vanadium alloy coating necessary as part of a reman process could be improved in hardness and durability by an optimized pulse laser remanufacture process, with laser cladding followed by laser shocking. This process was shown to enhance the friction and wear coefficients and increase the microhardness of the deposited layer.

3.6 EV and battery development

Today EV battery technology changing faster than many can carefully consider adopting EV as an option to travel. Campoverde-Pillo (Campoverde-Pillo 2024) looks at this fast-moving development and presents a systematic literature review on the reuse of electric vehicle batteries (EVB). Specifically, he is looking at the use of former EVB's as power banks for storing renewable energy from renewable installations. The end-of life of these batteries represents a major environmental problem as their design and materials were not planned for retirement, or re-use.

Whilst there may be now, and will certainly be in the future, a large surplus of EOL EVB's the desirability of utilising them in entirely different environments to those they were designed for – i.e. within a temperature-protected battery box on board an electric vehicle, controlled by an on-board BMS, a battery management system. There will need to be far more review of the existing challenges of technology, costs, and regulations in the use of these batteries within these newly proposed conditions. The eventual goal should be establishing a the carefully considered circular treatment of EVB's across their areas of usage, and what their total expected lifespan might be. The correctly placed sentiment of reducing the demand for

new batteries is likely to have a positive environmental impact, and ecological impact of raw material extraction processes.

3.7 Medical remanufacture

We would surmise that one gateway to the use of reman equipment is the acceptance of regulators and professionals at the elevated levels of decision-making within large organisations, and those acting as gatekeepers to new approaches and technological approaches within those organisations. With huge daily turnover of single-use equipment, and the importance of high-value imaging and sensing medical equipment, the NHS is in an ideal position to be an exemplar for driving the potential for safe re-use and regulation of reman medical equipment. The reality is the UK NHS currently has a ban (NHS 2017) on reman within their procurement - a search of the NHS 'Use of Resources' indicates no mention of remanufacture. As one of the highest users of primary materials in the UK, a total budget of in 2022/23 of £180.2 billion, and sixth on the world's largest employers, with 1.6M employees, there is no possibility of incorporating reman as a concept and source of products. (Bulut, August 2023). Even more concerningly, there is still no mention of remanufacture in the whole 'NHS Long Term Plan,' document, despite their stated commitment of " investing in exciting new technologies." (Ref: NHS LTP) .

Where medical equipment has reached the EOL from the developed countries' perspective, the principle seen commonly within reman is the transfer of those equipment cores and assemblies to less developed countries, where they may well be able – under regulatory support and OEM supervision – to be remanufactured to aid those countries without the funds to source new equipment of that type. Roy McFarlane mentions this in my primary research responses, when manufacturers he works with will pass up the reman opportunity and fit new replacements, moving the EOL cores into developing countries where more appropriate cost bases can happily incorporate their reman. Oturu et al (2021) investigated this concept and identified the difference the presence of critical medical items such as scanner and X-ray units can make in areas of child mortality, and female health. The scarcity of such equipment is no better example to demonstrate the widening gap between developed and developing countries as technology advances in the first whilst resources to hold even outdated equipment are not available in the second. The concept would provide local jobs at an appropriate level of technology, even for specific brand of equipment as a starting point.

In addition, the proposal would only be appropriate for cores designed to be disassembled non-destructively. The example of MEDECON Health care gives a working example of the successful practice of reman items into developing countries. Whilst the principle is sound, the facilitation of this is once again upon government in the exporter, and the importer, as the collaboration between companies in both regions is more readily gained than the regulatory acceptance to implement the practice.

3.8 Military remanufacture

In the search for literature and threads of current and previous research, it becomes increasingly apparent that the principle and practice of reman are fully understood in the military mindset and present in the designer's toolkit. This understanding is fairly universal across national militaries and international groupings across the globe. It would be my contention that the elevated level of wear and usage of established military platforms demands the constant inspection and renewal, but also the complete reman of units – 'cores' - that have been salvaged after catastrophic failure, whether by error or accident, or by hostile action. This also includes units due for upgrade when the flight or operation hours demand a full rebuild..

Long-term military platforms such as the CH-47 Chinook helicopter undergo an intense programme of rebuild by remanufacture, whilst both refurbishment and repair is conducted alongside on the same production line as brand-new versions, are being constructed. Warwick (Warwick 2018) reports that reman is a vital component of the CH-47 platform. The engineers point out that the rationalisation that allows remanufacture is only possible because new airframes are newly re-designed under current design technologies. This reduces the parts count to give a more repeatable assembly far more suitable for a thorough disassembly, remanufacture, and re-assembly process. This is where the OEM Boeing at their factory in Ridley Park, Philadelphia, excel at – the reman disassembly and re-manufacture of the upgraded units. Projected orders and preparation for future upgrading means that the CH-47 will be in service

past its 100-year anniversary, demonstrating that at least a part-circular economy can exist where the mindset, the security need and employment drivers are present as they are here.

To move across to China and her military, it is quite clear to Kania (Kania 2019) that the recent development of China's military modernisation has been deeply influenced by the PLA's concentration on the US military as both a model and a powerful potential adversary. With the mindset of the US military heavily set within reman, it is highly likely that the PLA takes the US lead on implementing the same approach, driven extensively by the potential of AI, as well as big data, cloud computing, and other advanced technologies – there is evidence of the PLA's funding of reman research in other references (Ren et al in 2021) elsewhere in this report. To quote China's General Secretary Xi Jinping, who also serves as Chairman of China's Central Military Commission (CMC), that 'Under a situation of increasingly fierce international military competition, only the innovators win'. Current geopolitical evidence shows this – at least at present – to be accurate when considering Ukraine's ability to innovate and use AI, hardware, software, and doubtless comprehensive remanufacture of failed military kit to hold off the numerically vastly superior Russian forces for approaching three years. Ukraine's ability to innovate at the 'coal-face' and adapt and re-purpose obsolete equipment (Oerlikon anti-aircraft guns, circa 1941, Lewis Guns, circa 1916), and notably out-mode platforms such as former Soviet-era cruise missiles, the US Bradley AFV. The Bradley, previously sidelined to military stockyards across the US, is proving to be one of the most effective armoured vehicles in this new terrain and battlefield tactics, of what is the first AI and advanced technology-dominated conflict, and surely the shape of military things to come.

3.9 IT and Smartphone remanufacture

Looking at who has access to a ready supply and variety of the 'cores' from the waste electrical equipment market, a business from my direct experience can adequately demonstrate the status of effective IT reman in the UK today. Blackmore IT, based in Wiltshire, are high-security data destruction and electronic and electromechanical dismantlers (Ref: Blackmore UK)

https://blackmoreuk.com/, Appendix 14) They are certified to work with the MOD, NHS, UK Government and the security and Court Services at the highest security levels. Alongside the mainstream business of data destruction and separation of electronic waste, the company have developed a market for second hand IT equipment. Amongst this is which is an extremely specific business stream for remanufacture of 'core' elements of the equipment they dismantle and remanufacture these into a broad range of bespoke gaming and graphics design computers, using top range IT equipment and components at large discount over new, but effectively equivalent, items. (Ref: Blackmore IT). The opportunity to custom-build to specific requirements at a large discount is a significant advantage over volume suppliers of new equipment, and custom builds, and a greater advantage over small to medium custom computer builders.

4.0 ADOPTION OF ADVANCED TECHNOLOGY BY REMANUFACTURERS

4.1 Divergent pathways, is new technology reaching remanufacture?

According to BS 8887-Part 2 (Bsi BS8887), in a definition far less complex than Ijlomah remanufacturing is an industrial practice of:

"Returning a product to at least its original performance with a warranty that is equivalent or better than that of the newly manufactured product."

Manufacturing is Europe largest employer within industrialized nations – 34 million people within the EU, 14.5% of GDP - a major indicator of development, and creator of 14.5 % of EU GDP (REF: 3 Europe in figures - Eurostat yearbook, 2010. ISBN 978-92-79-14884-2, European Union 2010):

The table below provides a summary of the findings by sector across the EU.

Sectors	Turnover (€bn)	Firms	Employm't ('000)	Core[2] ('000)	Intensity
Aerospace	12.4	1,000	71	5,160	11.5%
Automotive	7.4	2,363	43	27,286	1.1%
EEE	3.1	2,502	28	87,925	1.1%
Furniture	0.3	147	4	2,173	0.4%
HDOR	4.1	581	31	7,390	2.9%
Machinery	1.0	513	6	1,010	0.7%
Marine	0.1	7	1	83	0.3%
Medical equipment	1.0	60	7	1,005	2.8%
Rail	0.3	30	3	374	1.1%
Total	**29.8**	**7,204**	**192**	**132,405**	**1.9%**

[1] On-line survey, direct phoning, use of meta-studies and top-down analysis

[2] Core: a used part intended to become a remanufactured product

European Remanufacturing Network – WP 2.2 Remanufacturing Market Study – Final Report 20th October 2015. **(Appendix 3).**

Their overview table **(EC ERN 2015, & Appendix 3)** shows by far the majority 70% of reman in Europe is in key zones, Germany, UK (then an EU member) and Ireland, France, and Italy. Germany takes its place as would be expected as the major industrial giant in Europe, but with

France and the UK/Ireland together only account for half of Germanys reman volume. The distribution of aerospace in UK and France may account for Italy's lower reman volume.

Turnover	Benelux[1]	Central[2]	Eastern[3]	France	Germany	Italy	Medi-terranean[4]	Nordic[5]	UK & Ireland	Total
Aerospace	389	399	513	2,311	3,814	1,127	816	368	2,698	12,436
Automotive	395	652	692	754	2,370	699	790	273	766	7,393
EEE	111	230	578	355	646	592	311	106	190	3,118
Furniture	10	16	52	24	66	66	23	18	34	310
HDOR	160	227	343	633	1,108	541	380	242	509	4,142
Machinery	44	45	81	108	336	199	70	53	90	1,026
Marine	11	2	15	3	11	8	13	5	6	76
Medical equipment	36	70	104	112	316	61	68	83	121	971
Rail	11	46	41	22	61	39	48	27	49	343
Total	1,167	1,687	2,420	4,322	8,728	3,333	2,519	1,173	4,463	29,813

Notes: [1] Benelux: Belgium, Luxembourg, Netherlands
[2] Central (excluding Germany): Austria, Czech Republic, Slovenia
[3] Eastern: Bulgaria, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, Slovakia
[4] Mediterranean (excluding Italy): Croatia, Cyprus, Greece, Malta, Portugal, Spain
[5] Nordic: Denmark, Finland, Sweden

European Remanufacturing Network – WP 2.2 Remanufacturing Market Study – Final Report 20th October 2015. **(Appendix 3).**

The ERN survey does provide a useful indicator of both volume and distribution. Additionally, the ERN survey looked at the motivation for, and the barriers to, reman across Europe. As noted, the motives include higher profit margins, environmental responsibility and the circular economy, strategic advantage within sector and increasing market share. Interestingly other motivations indicated are alternative business models, resource security risks, customer pressure to embrace circular economies, warranties, reduced lead times against new production.

Barriers emerging from the survey include customer recognition of the value of reman, the access to 'core' and the quality of these, and the limitation of labor skilled sufficiently to undertake reman, and the costs of training and sourcing these staff.

The survey conjectures that with supportive EU and member state governmental policy, the growth of reman could rise from 30Bn to 70Bn to 100 Bn, employing a potential workforce between 450000 and 60000 at those levels,

4.2 Barriers to incorporating advanced technologies

It is clear that at SME level of business, there is limited transmission of current information and data on what advanced technology and digital transformation can do for businesses of that size – 40% of SME manufacturers say digital transformation does not feature in their business plan. From personal experience of working with SMEs on digital transformation, to benefit by implementing new technology small businesses have to have the technical capability, market awareness and the interest to build a technical and financial case for broadening their capabilities into advanced technology. Without this, SMEs rightly perceive the risk levels of approaching advanced technology as too high and remain as non-starter in danger of being left behind their competitors. This is recognised by an initiative led by 'Made Smarter Northwest' who have produced a recent programme to disseminate their 'Made Smarter Roadmap for SME Manufacturers' (Appendix 12) which is a hand-holding approach to help manufacturers progress towards adopting advanced technology with authority and capability. Recognition of the barriers perceived by the workforce, the process fosters a digital culture to adopt, building trust that the process is not a labour- trimming exercise and countering the perceived risk barrier to capitalise on opportunities to move operations into a digital understanding and capability.

Yang S, in 2018 looked at the range of barriers to remanufacturing uptake, and restricted – at that time – 60% or reman activities to within the aerospace, automative, and heavy-duty off-road sectors. A major obstacle is the lack of standards and definition of reman and the quality achieved by the processes, and the resistance of government to the free movement of reman goods across trade barriers. The approach to product design also heavily limits reman, as without the full attention to a 'design-to-reman,' or DFRem mindset, adopted by industry, the ability to disassemble non-destructively rules items out of the reman opportunity. The level of market demand for reman will limit the reman of items, as will the unavailability of suitable 'core' units as reman raw material. Although recent moves noted elsewhere in this report demonstrate the counter argument - automotive reman is thriving and a growing sub-set of after-market and OEM business models. Significantly, Yang also lists the skills and technology challenges noted above, and the limited sharing of information to build confidence in reman methods, quality and viability.

5.0 BUILDING CUSTOMER ACCEPTANCE OF REMANUFACTURE ITEMS

5.1 Perception of the customer to remanufacture

The value of a remanufactured product is currently not understood by those outside the industries which use and rely on this , due to unfamiliarity with the concept. This is because reman is too remote for them and unless they are aware of the markets where high embodied, and actual value, of the core equipment they rely on in their commercial operation, the likes of machine tooling, and mining/heavy construction, aviation. The reputation of 'second-hand' to the general population certainly in the UK, is negative. However, in the automotive market the high price of EV's and lack of trust in the rapidly emerging tech has led to a resurgence in second-hand vehicles, whether by OEMs, or by commercial operators such as 'Spoticar,' where reconditioned and warranted vehicles are presented as viable alternatives to new, or untrusted sellers of second-hand vehicles. Whilst this is markedly not reman, it is a pathway to acceptance of the re- concept to a public increasingly beleaguered by cost pressures across the board. Increasing acceptance in this context can potentially drive wider acceptance of reman into wider assets and markets.

5.2 Changes in monitoring condition of 'core' units

Operating complex manufacturing and mobile equipment depends upon the safe and consistent operation. Inclusion of a real time information channel reporting on condition, is vital to provide the intervention when to maintain, discard, or remove and replace the asset whilst remanufacture can proceed to bring the asset to 'as new' operating condition. Prediction and management of condition is an identified barrier into remanufacture, and the implementation of IoT sensors and communication of wear and performance data is crucial to bringing reman forward in asset management.

With increased data availability and communication with remote equipment, the inclusion of a computerised maintenance management system (CMMS) can more easily monitor and inform on asset performance. Not only can the patterns within performance or wear be tracked by the IoT sensors, but communication linked to the digital twin, known failure modes, and asset history can allow intervention and replacement for reman at the optimum time. Whilst the digital capability is certainly there, it's vital that the CMMS interface is

understandable and able to be read and actioned by all levels of skills involved in this process. The presence of code or programming in the configuration of the CMMS, and the unwillingness to match the interface to the level of skilling available, or where that is attainable at acceptable commercial cost, the likelihood is that readily attainable asset knowledge will remain as a barrier to reman.

Kurilova indicates that the common main challenges for reman are core quality and availability, the timing of the reman process, and assured quality of the finished products. Detailed work with four examples showed that challenges included the degree of resource planning against an uncertain core supply, difficulty in assessing core condition, lack of OEM information on the connected parts to the core, and a lack of carefully considered planning of the reman process.

Kurilova proposed whether lean principles could ease most of these challenges, which are internal organisational rather than external, from and to the market.

The application of Lean principles are commonly applied to improve manufacturing flow and organisational understanding – and Kurilova notes that few studies had looked at the lean principle for significant improvement to reman [processes. Their case studies looked at the lean tool VSM to highlight production difficulties from the operational staff cross section.

Common ground is found that remanufacturing itself is complex and difficult to manage due to company internal and market external challenges - as it represents a common theme applied to vastly different products. Lean application into delay issues from hazardous material management derived from residues on the core and assembly can delay the 'core's' progression through the process, and eventual re-issue of the reman assembly.

3 levels of challenge were proposed – in legislation and environmental regulation, in customer preference and in the introduction and adoption of technological advances.

The paper suggests concrete lean-based improvements to tackle remanufacturing process challenges and improve lead times. Reman companies clearly face similar challenges with cores as a basis for reman, and despite the advent of advanced technologies, the application of lean to reman may well assist in the easing adoption of reman.

6.0 BUILDING BUSINESS ENGAGEMENT TO REMANUFACTURE

6.1 Extent of the opportunity for remanufacture to create roles

We have already seen the practice of EOL cores and assemblies being exported over the developing countries, in favour of being reman in the original country. This is reported by at least one of my interview correspondents. The displacement of the reman to a developing country brings with it challenges of technology level needed d, against the current technology level in the destination, a developing country. The tendency would be for the skill levels to stay static, where the government and business leaders may be missing the point of the opportunity this represents. Chau 2021 recognised this, and further pointed out that the cyber-physical systems and the IoI architecture in the destination should both be carefully considered to ensure that higher skill levels can be applied to the reman process, not just the low skill tasks of dismantle and rebuild, which does not enrich the developing country's, labour capital and education.

Qui in 2022 examined the effects of environmental taxation on reman – with the increasing onset of carbon-based taxation, even in the much-maligned industrial environment of China, the environmental advantages of reman have not escaped the governments attention. The lower environmental impact and reduction in production costs attracts both legislators and businesses, although the increase in production planning, availability of raw material 'cores' and ongoing markets are still a barrier to reman consideration by business. Qui's view is typically very much an academic one. Where the real-world situation demonstrated by CoreCentric demonstrates the simpler the reman proposal and the more selective the options available, the more likely the reman and sustainable parts' model is to succeed commercially.

6.2 Support from Governmental and Regulatory sectors

Government and policymakers' guidance on reman in the UK has been inconsistent.
As far back as December 2014, the Rt Hon Caroline Spelman MP in the report of their Parliamentary Group inquiry (Ref PPRG, Appendix 4,5) stated: "Although opportunities for remanufacturing are far-reaching, Government and industry need to work together to develop its full potential" In the PPRG Report "Triple Win: The Social, Economic and Environmental Case for Remanufacturing", in December 2014, Report sponsored by the quasi-Governmental 'High Value Manufacturing Catapult'. To demonstrate why was seen

then as necessary, reman then was estimated as less than 1% of UK volume- wider European norms should realistically be nearer 20% . The PPRG details that the Engineering Employers Federation – the Manufacturing Organization- estimate of K reman is £2.4bn, 2016, but the potential would be easily £5.6bn – if supported and developed. Total UK output 2016 was £164bn. This might well create over 100,000 jobs, but no Government strategy is there to promote this. In UK Law and Standards, reman does not exist, and in the largest employer in the UK, the NHS, reman items are barred from procurement by the NHS .

The report indicated that reman was already recognized as a critical part of manufacturing link to environmental sustainability, and vital to sustainable growth in the manufacturing sector. The weak communication the UK has between centres of expertise – linkage between research and operational manufacturing is just one, means that the potential the UK has to develop reman is far behind that possible in the more connected manufacturing communities in the US and China – reman is just not getting through in the UK. There is an enormous potential for reman by bringing jobs back to the UK as re-shoring, using established skillsets needed for reman to legacy equipment and building in advances and upgrades to that legacy equipment. The Report recognized that to maximize opportunities in reman, much work would be required by Government and industry to address barriers already facing reman to be surmounted. The statement was made in the Foreword, that "(UK) Govt and Industry should be ambitious in aiming for the UK to become a world leader in this field." Has the UK been capable of mobilizing the detailed multi-sector, multi stakeholder thinking that could achieve this – my contention would be no.

7.0 BUSINESS MODEL EVOLUTION - CHANGE TO BROADEN REMANUFACTURE UPTAKE?

7.1 How does advanced technology affect the manufacturing business model?

An example of the new business model and 'robots as a service' s model demonstrating an accessible entry path into advanced technology using 'pay-for-productivity', where the user pays for the output only, - Formic was founded in the US by Misa Ilkhecki and Samin Farid to allow small and medium sized business access to productivity boosting automation on a low hourly usage cost and guaranteed performance. Formic 2024 (Ref: https://formic.co/about accessed 1/1/24)

Slowing the accessibility to robotic design for manufacture and remanufacture remains the cost and availability of designers who can design these systems and implement them in the SME and medium company workplace - Etienne Lacroix formed 'Ventia' as a means of producing robotic system design on a 'Lego' basis, allowing development of individual advanced technology robotic systems by access to unified system design cutting through the brand specific design skills to allow 'democratised' design of robotic systems. 'Coding-free' automation design, allowing usage of the systems needed for effective remanufacture at lower cost for growing and established companies at lower levels of automation development. https://vention.io/resources/video-tutorials/discover-machinelogic-75 accessed 1/1/24)

Ready Robotics inc, founded by Dr Kal Guerin and Ben Gibbs (https://www.ready-robotics.com/about/weareready) which has developed 'ForgeOS', which is a user-friendly touch-screen HMI interface collecting the control systems of robots, peripheral systems and material and consumable supply. In this way a no-code, low-code or all-code approach allows for all levels of staff readiness for advanced technology at accessible cost for growing manufacturing companies.

With the focus on the practicalities of advanced technologies on manufacturing on manufacturing, and remanufacturing progress, the logistics of supply chain and final reman product delivery have been sidelined in favour of the process improvements and operational gains from advanced manufacturing are embraced. However, the studies in barriers to reman (Kurilova) are clear on the limitations of the supply chain identifying, tracking, and providing the used, (but in reman terms, raw) materials to the reman site. The digitalisation of logistics

for the 'core,' and related assemblies the core is dependent upon for full rebuild for parallel reman, , should be considered together.

Kayicki sets out the required digitization process and supply of cores and return to customers covering product variants, connected processes and assemblies, and autonomous management of the supply chain process. He rightly sees this as an essential foundation to the manufacturing and reman process. As a main aim of the circularity business model against the traditional linear model - the large opportunity to reduce emissions – this seems possible to be harnessed from supply chain logistics by the introduction of advanced digitization, conjectured in some places (WEF, 2016) as between 10 and 12% in nine years by 2025. This is now a year away and there is little evidence that digitalization has been able to attain anywhere near these emission savings. In fact, the WEF on July 2024 (WEF 2024) recognised that digital transformation targets were "*far from being achieved*", so the resulting emission savings must be some way behind that planned in 2016, above. This ref conjectures autonomous trucks will make $30 billion impact from savings in fuel costs, employee costs and insurance, and drones would achieve $20 billion business impact by faster and more efficient 'last-mile' delivery. Although today we see the huge impact drones can have on some areas of the industrial process – the continuing conflict in Ukraine is dominated by the highly advanced and quickly developing weaponization of small, 'FPV', or personally controlled, expendable drones – the much-vaunted '..the supplier can get you anything anywhere fast with a drone' so far seems still to be a marketing promise, not a reality or strong contributor the circular economy.

Kayicki did indicate that live research showed logistics cost, delays in delivery, reliability were already in process in improving logistics with digitization. However, he points out the that any promised positive societal impacts improved health, lower accident rates did not show any improvement – indeed commonly he saw the threats perceived to work patterns were a real barrier to full acceptance to digitalization of the logistics. Kayichi's study is localised to Turkey, and restricted to societal, environmental and economic implications of digitalisation, I think the message should be a strong one with wide implications that the if any impacts – and societal impact is expected to be greater than the economic impact of digitalization , then the lack of linkage between the businesses, the regulatory authorities and the governmental policy will never allow the possible impacts to be realised.

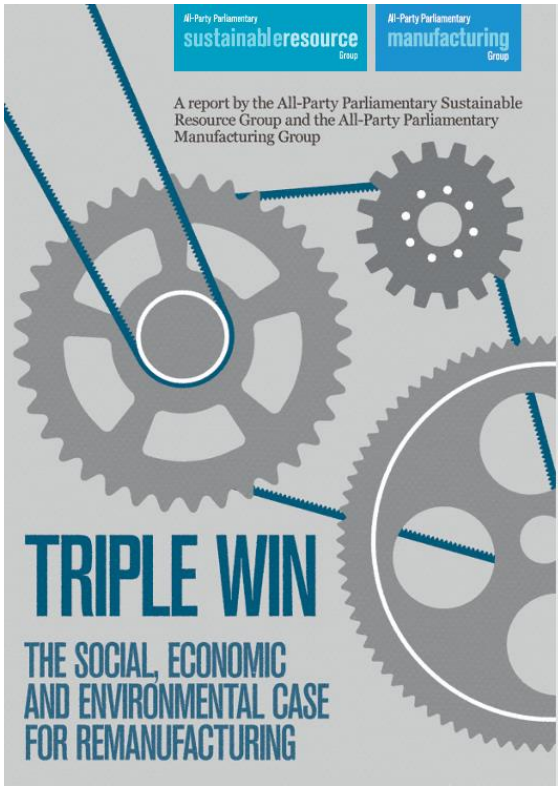
The Great Recovery was a project by the RSA working with Innovate UK between 2012 and 2016 – looking at the challenges towards progressing the circular economy through design. Their remit was to disseminate the underlying theme that design of product is at the heart of its suitability for circularity, rather than linear and entrenched 'take, make and discard' mindset. The system as a whole need to be considered, not just the product, its origin, materials, lifetime to an end-of-life, and disposal. They use the term co-creation to stress the importance of involvement across who touch the product's lifespan, designers, material scientists, manufacturers, brand, and retailers, but importantly, and essentially: policy makers and legislators, government, investors, and academics.

FRSA David Brunnen argues that the basis of understanding the circular economy is the understanding of ownership of an item. whether you own the item or own its use for a period of its circular life cycle. If this is the case, do you require so much capital, and incur so much business debt? The re-working of business and the way resources flow into and out of it, including the finance to maintain the ownership and use of assets. He argues that the real change in circular economy thinking (as at 2016), is a realization of how complex the real commercial and manufacturing world is, compared to the fine thinking, and intentions, of those promoting the circular economy from the idealist, and academic, viewpoint.

The onset of circularity do not need to be mandated – Brunnen raises that Schiphol airport does not buy light bulbs: the airport buys 'light as a service' – which allows the manufacturer to maintain ownership of the lighting, then replaces them taking the used items for remanufacture. It is the manufacturer who is incentivised to minimise his costs and maximise the service to the client, at the same time maximise resource use and energy use by the client – a win-win on all counts.

My view on this is we have to view the onset of a growing circular mindset in terms of the expanding economic facilities and approaches away from our conventional business accounting – disruptive elements such as crowdfunding for ownership, the sharing economy – illustrated by common 'car clubs' and 'take and use' cycles of the Boris-Bike type. Add into this the progressive improvement in connectivity brought by the onset advanced technology, including network insights on item availability and location and working status, open data

and transparency, and collaborative advantage, and the ability to assess the role of a ream product rather than a new item, can be wholly differently assessed by a business with the right mindset.



'The case that '…legislation is needed for …,' such as that made by the 'Spelman APPGM' Report 'Triple Win' (Ref: Spelman, Caroline.MP (Rt Hon), Appendix 4), implies "…that nothing is going to happen without legislator and Government taking the lead and mandating the necessary changes that will have the desired effect." However, as we note above, with the right information on the holistic benefits of reman to cashflow, protection of jobs and progression of current roles into roles incorporating the circular economy, then reman will be promoted by the OEM's and independent remanufacturers alike. Indeed it may be that legislation or policy may need to be cleared away to prepare the path for reman.

To attempt to assess who in the supply chain would be suitable to engage in the choosing of supply chain partners, Kurilova-Palisaitiene. (Kurilova-Palisaitiene 2021) presented a tool she has developed she has termed the 'Remomteter', to measure businesses' readiness to pursue reman. To continue the supply chain readiness theme, Dai, L., Peng, J., & Zheng (Dai, L., Peng, J., & Zheng 2024) sets out their recent thinking on decision making for reman using advanced technologies. He demonstrates that the low level of low carbon awareness and education in a supply chain manufacturer result in disadvantage against the OEM when competing for reman of the same core supply chain. Perhaps unsurprisingly, the design methodology approach from the two would be very different from their relative standpoints of authority of the original design, and the strategy to reman the EOL item. But conversely, and interestingly, the potential supplier chain partner is shown to have more flexibility as his carbon awareness increases with experience of successful reman contracts.

8.0 PRIMARY RESEARCH – INDUSTRY INTERVIEWS AND DATA GATHERING

8.1 Method and rationale of interviews and data gathering

To gather data and industry opinion on reman and its development alongside a range of advanced technologies, the author sought engagement from a range of manufacturing and consultancy organisations. This included personal contacts and business organisations, those referred by Alan Mumby, and other referred contacts. The list of individuals and organisations canvassed for assistance is included in the Appendix 6 by direct interviews,

In terms of the extent of the survey, the survey work did not warrant any specialist sampling methodology. However, as the principal of snowball sampling (Berndt 2020) can be a useful sampling strategy, the selection of some initial participants were made and further referral contacts from those were added into the survey.

A range of message types were sent to the selective recipients and groups, selected from my own contacts and memberships. These contacts and organisation communications are included in Appendix 7, with their responses recorded and included in Appendix 8.

The questions asked of all survey participants are listed below. These are also listed in Appendix 9 :

1. Are you aware of, and if so, how do you perceive re-manufacturing as a technique?

2. Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?

3. Do you use re-manufacturing within your own company operations and skill set?

4. Do you use suppliers who supply re-manufactured items to your business?

5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?

7. Are there recent technological advances that might encourage you to use or consider re-manufacture?
8. What would you see are the main barriers to your sectors using re-manufacture?

9. Are there any legislatory or Government policy changes that would encourage you and others to re-manufacture within your sector, or the suppliers you deal with?

10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?

Depending upon the type of meeting, answers were received in the following manner:

- direct email back – single participant, detailed response
- transcript from a zoom meeting - 2 participants
- commentary distilled from face-to-face meeting - 3 participants

The responses are summarized in a 'Remanufacturing Survey Findings Matrix', which can be found collectively in Appendix 10, with individual responses within the relevant section below.

8.2 Results and Discussion.

8.2.1 Roy McFarlane, Total Productivity Solutions.

Roy McFarlane is a production engineering professional, working in the manufacturing industry. In general Roy's responses are relatively negative towards reman. He is clearly aware of reman as a discipline, but he considers the equipment he sees – largely production equipment for FMCG production- to be unsuitable for reman.

Roy adds some additional comments covering direct experience and comment from his clients. He commonly sees used equipment being sent abroad for reman or other refurbishment on removal at EOL – where he does see reman it tends to be for high end

Remanufacturing Survey Findings Matrix	
Remanufacturing question	Roy McFarlane Total Productivity (first person written responses)
1.Are you aware of, and if so, how do you perceive re-manufacturing as a technique?	Yes, I m aware of remanufacturing as a technique, Most often commercial equipment is unsuitable for remanufacturing
2.Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?	No, typically remanufacturing is more expensive (due to dismantlement costs)No, customers want lengthy Guarantees and Warrantees and typically don't trust reuse of components
3 Do you use re-manufacturing within your own company operations and skill set?	No, the extent is refurbishment and reuse of structural elements only
4. Do you use suppliers who supply re-manufactured items to your business?	No, the complexity of parts means that it is too costly to remanufacture components and be competitive.
5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?	No, the extent is refurbishment
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?	No, refurbishment with reuse of certain components is routine but not remanufacturing.
7. Are there recent technological advances that might encourage you to use or consider re-manufacture?	No, the introduction of carbon fiber and composite materials makes reuse and remanufacture unworkable. The majority of components are complex assemblies (motors, circuit boards, cables, safety switchgear and solenoid actuators or other mixed material components)
8. What would you see are the main barriers to your sectors using re-manufacture?	Cost Complexity of disassembly and remaking Validity and compliance of legacy materials
9. Are there any legislatory or Government policy changes that would encourage you and others to use re-manufacture within your sector, or the suppliers you deal with?	No, the Machinery Directive and associated safety and warrantee liabilities remain the most significant regulatory barriers for remanufacture.
10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?	Not specifically. I am aware of several European machinery manufacturers that have explored remanufacture and none have found it viable from a cost and compliance perspective.
Other comments	CTI (also in Italy), Bhargab (India), Coveyor (Bristol), Gemma lighting (Fareham), Herma printers (Germany) and Flexlink (Intenational); all state that they may want to but are unable to guarantee products that reuse parts, and it is much more expensive to reprocess materials to an "original supply" standard.
continued….	Bosch Packaging (Netherlands) reuse structural components only, as part of a buy back scheme, but generally only refurbish on the request of a customer – in batches to improve cost effectiveness.My contact stated that the refurbishments with high percentages of reused parts, are typically at the request of customers like Unilever.
continued….	My contact stated that the refurbishments with high percentages of reused parts, are typically at the request of customers like Unilever.

customers such as Bosch, or Unilever – one would conjecture that these are clients more likely to have a sustainability reporting agenda.

On costs, Roy perceives reman as typically more expensive, which is at variance to direct reportage in both academic and commercial references in this report. The dismantling costs are seen as a barrier, and we do know that this arises as a serious consideration. The guarantees and warranties demanded are too high, and clients don't trust reman.

What he sees is really refurbishment, and of major structural elements only – in addition the parts he sees are too complex to be economically reman. Neither does he use third parties to reman tools for his businesses.

Roy fails to see any recent advantages in reman and the use of advanced technology. In fact, the introduction of composites are making reman unworkable, ".*The majority of components are complex assemblies (motors, circuit boards, cables, safety switchgear and solenoid actuators or other mixed material components."*

Roy's stated barriers are 1) cost 2) complexity of disassembly and remaking, and 3) validity and compliance of legacy materials. In legislation terms, Roy sees the 'Machinery Directive' (see Appendix 11) and associated safety and warrantee liabilities remain the most significant regulatory barriers for remanufacture.

In closing, Roy gives his views on past reman experimentation by his clients – he is *"aware of several European machinery manufacturers that have explored remanufacture and none have found it viable from a cost and compliance perspective. In context these examples service or supply into the food industry that has very high material controls and customers demand a high degree of reliability in very arduous environments and very high expectations on safety and very competitive pricing".*

His overall impression is that competition from China, India, Malaysia and Indonesia makes remanufacturing uncompetitive, although in the case of PCB 's, most of his clients use 2 UK PCB repairers for electronic refurbishment.

8.2.2 Irma Gilbert, Authentica Car Parts

Irma introduced autentica – at the time of the discussion they are an early stage start up producing 3D printing of car parts, current and classic, including Porsche, Cadillac, Volvo. They aim to slimline the remanufacturing process by providing scarce or otherwise prohibitively expensive parts that enable vehicle restorers to complete reman builds of vehicles because of EOL parts that are not readily available.

The ability of advanced manufacturing technology- in their case additive manufacturing/3D printing- enables them to provide a part derived from an OEM original or from original manufacturing information and designs/drawing data. This is achieved by a point-cloud scan of the item, which proceeds to design, and then 3D printing in the correct material, or by direct data transfer into the CAD design of the original design information and geometry.

The part is then post-processed by milling or other 'subtractive manufacturing' to provide the required part geometry and finish. The 3D printing can be either at autentica, or by file transfer facilitated with NFT security, the item can be 3D printed by the customer remotely at his works, using a one-time secure code. NFT is a data file, stored on a blockchain databank, which is sold as the access to the 3D print file. The NFT is associated with the 3D part, and it

confers licensing rights to produce the part once only and use the asset for the specified purpose. Files have been sent and parts produced remotely in Spain, Singapore, Malta, Brazil, and Chile.

Remanufacturing Survey Findings Matrix

Remanufacturing question	Irma Gilbert Autentica
1.Are you aware of, and if so, how do you perceive re-manufacturing as a technique?	Yes
2.Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?	Yes
3 Do you use re-manufacturing within your own company operations and skill set?	Yes
4. Do you use suppliers who supply re-manufactured items to your business?	Yes
5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?	Yes - items printed elsewhere using our coding.
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?	Yes
7. Are there recent technological advances that might encourage you to use or consider re-manufacture?	Yes, entirely..
8. What would you see are the main barriers to your sectors using re-manufacture?	Technology adoption and costs
9. Are there any legislatory or Government policy changes that would encourage you and others to use re-manufacture within your sector, or the suppliers you deal with?	No
10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?	No

Many areas of the work they are doing are very recent development and some under live development as the offering proceeds. Irma notes the concept would not have been possible as a package until the last 12 months or so. These assembled techs needed to combine to allow the overall process - include the scanning and design analysis, the selection of 3D printing materials, the NFT, and the availability of the 3D printing equipment at autentica and at the remote locations the NFT tokens are sent to.

Iram firmly believes the autentica business model and performance so far is the key to a wider use of reman in reducing company costs and timescales to bring EOL vehicles back to use, reducing carbon usage of this process, reducing carbon in transportation methods of the parts, and in providing reasons for upskilling within the customers they are dealing with as customers.

In contrast to Roy, Iram is entirely positive about the role reman plays. In counter argument, she is dealing with high-end companies producing projects where marginal cost is not an issue, so the direct cost of reman is less likely to be a disincentive to the reman process.

8.2.3 Chris Probert, Aber Instruments

Chris works in a field of high-integrity instrumentation and measurement of biomass recording and growth.

He is positive on reman, if appropriate, and reman of items should not be an issue if the design has been approached correctly – i.e. 'designed for reuse'

Remanufacturing Survey Findings Matrix	
Remanufacturing question	Chris Probert Aber Instruments
1.Are you aware of, and if so, how do you perceive re-manufacturing as a technique?	Yes
2.Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?	No
3 Do you use re-manufacturing within your own company operations and skill set?	No
4. Do you use suppliers who supply re-manufactured items to your business?	No
5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?	No
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?	More Detailed analysis
7. Are there recent technological advances that might encourage you to use or consider re-manufacture?	No
8. What would you see are the main barriers to your sectors using re-manufacture?	Verification of performance and clean condition.
9. Are there any legislatory or Government policy changes that would encourage you and others to use re-manufacture within your sector, or the suppliers you deal with?	No
10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?	No.

Chris' customers at Aber Instruments – are strongly biopharma companies, their sensing equipment being returned for 're-calibration,' rather than reman. This ensures the correct accuracy which is crucial in biopharma.

The number of autoclaving cycles of this returned equipment is crucial, there is a finite limit to the number of autoclaving cycles.

Re-sold equipment is always re-calibrated and any consumables replaced, due to the risk of cross-contam into the workplace at Aber Ins, and carrying that on to following customer. This form of highly accurate measurement is highly industry regulated by the controlling bodies.

Virgin products produced are calibrated – out-of spec products are re-calibrated.

Challenges exist in certification of any products that have been in end-contact with customers sold products – stainless steel is a re-usable material in this, but single use plastic are not.

'Headamps' are meas equipment sitting outside the sterile environment, which are re-usable if irradiated, or autoclaved.

Looking at control systems, increasing miniaturization, helps with the development at Aber Ins. Where re-use is proposed, it is a factor that ongoing development makes the 'older body' less desired, or to accept and incorporate upgrades, etc. In other cases, the rapid advancement of microchips means that there is more of an appetite to move on to avoid the older tech lagging the equipment's operation.

So, what barriers to reman does Chris see?- in his industry, the risk of biohazard and regulatory compliance.
The overall aim being the reduction in carbon footprint – at the same time minimise the production of exotic – hard to deal with – materials in these manufacturing processes.

8.2.4 Eoin Bailey, Cela Steel UK

Eoin regards the modification of steel – they do not produce steel, they process it – as remanufacture in the sense that inclusion of scrap and modification of constituents for particular needs is reman of the product. The current refit at Celsa will drive the understanding of quality assessment and control for this reman steel.
Eoin raised the production of rebar and structural steel as a reman of the base steel billets and plate, with the return of core product in terms of rebar or structural steel being assessed for reuse in that form or recycle/reman into ongoing other steel products.
There is still great industry resistance to decarbonisation – wind turbine blades are still buried and the re-use of this and other products is limited due to aversion to unjustified and misunderstood risks in reused/reman items. The assumption that risk is there is killing the initiative to proceed with circularity.

Great focus should be on 'design for disassembly,' keeping fibres of material intact, (old yellow page phone books were from repeatedly recycled short-fibre paper pulp that had no other useful application)

Remanufacturing Survey Findings Matrix

Remanufacturing question	Eoin Bailey Celsa UK
1.Are you aware of, and if so, how do you perceive re-manufacturing as a technique?	Yes
2.Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?	Yes
3 Do you use re-manufacturing within your own company operations and skill set?	Yes
4. Do you use suppliers who supply re-manufactured items to your business?	Yes
5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?	No
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?	re-use and re-purposing of buildings
7. Are there recent technological advances that might encourage you to use or consider re-manufacture?	N/A
8. What would you see are the main barriers to your sectors using re-manufacture?	None
9. Are there any legislatory or Government policy changes that would encourage you and others to use re-manufacture within your sector, or the suppliers you deal with?	EOL vehicle and product legislatation.
10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?	No

For fuller implementation I4.0 methods and to aid reman and circularity legis is needed – policy changes – such as the ***Well-being of Future Generations Act*** the requirement for social value in public contracts is also driving more sustainability. This is fine, but Chris feels the eventual strategy applied does not always follow the legislative vision.

There is a developing trend – company 'Material Index' https://www.material-index.co.uk/index.html is helping the construction industry become more sustainable through material reuse – they provide pre-demolition audits and material sourcing from those arising from the demol.

There is also WLCA – whole life carbon assessment of buildings and products – which does capture the value of re-use.

It appears to Eoin that the automotive ind is not on board with circularity (differs from what I see in CoreCentric), being focussed still on linearity, where the economics are not critical. The End-of-life vehicle directive is requiring firms to disassemble responsibly.

This linearity is the same mindset as it was pre-Ind rev 1, in 1600 – there needs to be an 'attitude to ownership' that develops in terms of what happens afterwards.

8.2.5 Jon Peck, Electric Classic Cars Limited

ECC cars are remanufacturing the whole vehicle, by taking working classic vehicles with working engines, removing engines, fuel system and exhaust system out, and remanufacturing the car with replacement and modified electric drivetrain and new fuel system, which is a battery pack.

Remanufacturing Survey Findings Matrix

Remanufacturing question	Jon Peck Electric Classic Cars
1.Are you aware of, and if so, how do you perceive re-manufacturing as a technique?	Yes, the re-making of original goods in verified condition.
2.Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?	Yes
3 Do you use re-manufacturing within your own company operations and skill set?	Yes
4. Do you use suppliers who supply re-manufactured items to your business?	Yes
5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?	Yes
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?	New manufacture methods.
7. Are there recent technological advances that might encourage you to use or consider re-manufacture?	N/A
8. What would you see are the main barriers to your sectors using re-manufacture?	Cost
9. Are there any legislatory or Government policy changes that would encourage you and others to use re-manufacture within your sector, or the suppliers you deal with?	No
10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?	No

ECC also remanufacture the electric motors, commonly Tesla Model S motor. For Land Rovers these are turn upside down so that it can run in a different configuration than its original.

They change out the gearing to put in a new gearing - for defenders, they have a 4.5 to one or a 4.1 to one gearing as opposed to a 9.37 to one. The differential is swapped fora limited slip differential to improve them for the use that we are putting them to. So those are remanufactured.

They also remanufacture EV batteries, taking battery modules from Tesla Model S or the VW ID's and making our own

battery packs using those. So again, that is remanufacturing where they aren't just taking something out of a car and using it as it is in another vehicle, ECC are actually changing the configuration and remanufacturing them to suit our needs and purposes. But there are different levels of remanufacturing to their work.
In terms of the functionality of it, you are making it, the whole point of putting the drive in is that it is actually a greener idea. It is a whole greener approach to the thing.

ECC provide heavily researched looms for their vehicles and for kits for competent mechanics and enthusiast to convert common classics they see for conversion to EV.
Porsche 911, Porsche 912, Porsche 914.The classic Mini.. Beetle. The Defenders.

ECC leave the gearbox in place and commonly connect drives to an original gearbox. Sometimes that has to be upgraded, but it depends on the power that is being put through it and the requirements of the client.

Upgrading brakes and suspension is fairly standard thing to do. But if it has not been done, then that's something ECC obviously look at.

Gear amendments are common, ECC did that with the little bubble car, the BMW Isetta. We locked it into third gear and then you do not use a gear stick anymore, it's just forward, neutral and reverse with a little twist knob.

8.2.6 Rhys Jones, P A Group

Rhys Hughes is a Director for P A Group, near Ruthin. They manufacture standard and bespoke pallets for a wide range of haulage and industrial customers. Their own drive for some years has been to try and reclaim broken and otherwise unused pallets, return them to their factory and assess the opportunity to remanufacture the pallets back into fully operational standard pallets.

PAGroup assess the degree of damage and select only those with a maximum of three or fewer broken or missing elements. These are then remanufactured into complete pallets and brought back into use. (Information sheets from PAGroup are included in Appendix 16).

Remanufacturing Survey Findings Matrix

Remanufacturing question	Rhys Jones, P A Group.
1.Are you aware of, and if so, how do you perceive re-manufacturing as a technique?	Yes
2.Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?	Yes
3 Do you use re-manufacturing within your own company operations and skill set?	Yes
4. Do you use suppliers who supply re-manufactured items to your business?	Yes
5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?	Yes
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?	Yes
7. Are there recent technological advances that might encourage you to use or consider re-manufacture?	Yes, ID chips for recording product flow
8. What would you see are the main barriers to your sectors using re-manufacture?	Cost of uprating equipment.
9. Are there any legislatory or Government policy changes that would encourage you and others to use re-manufacture within your sector, or the suppliers you deal with?	No
10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?	No

Those too broken are disassembled using jigs and banded saws to cut through nails, not wood, and any timber elements greater than 800mm are retained to repair other incomplete pallets. Elements shorter are saved and chipped to make animal bedding and other products. Longer elements tend to be either 2.4m or 1.2m to build the largest standard pallets.

PMGroups focus is to bring the minimum amount of virgin wood materials into remanufacturing the pallets. PAGroup's customers are keen to have a reman of their broken pallets, as it helps them to report sustainability improvements and carbon reduction by using PAGroup to bring those back into use. The global insulation and chemicals company Knauf are a major customer, with factories near to PAGroup, and in South Wales.

Businesses who were deciding to leave PAGroup in favour of a cheaper second-hand pallet. This would have meant a degree of double-handling for the client, losing them time and efficiency. PMGRoup could take the initiative by using the remanufactured pallets at a lower cost and passing on the green credentials and carbon saving on reman to the Client, to report in his sustainability report. The return of broken pallets to PAGroup helps the client with lower disposal costs for the (to them) unusable pallets. This decision has meant a retention of £100K within the PMGroup business per annum, the reman capability acting as a differentiator for PAGroup.

PAGroup terms these remanufactured pallets 'tree-saver' pallets, as they are exactly that. Since 1998, PAGroup also use an effective 'marketing wheel', first used in 1998, to illustrate the reman principle to customers and clients – in this way the any potential negative perception of clients to the reman 'tree-saver' pallets is intercepted before it can arise.
The handling and cutting tech has been developed by PAGroup but is simple and amazingly effective at the fast stripping of pallets to elements, there are more effective robotic units to do this, but PAGroup will move to those when the business model allows the £350K cost.
Customers are motivated by new 100% virgin wood pallets – however they are more so in the reman pallets if sustainability information on what we are doing with their waste, or what kind of pallets we can supply them, or repair their pallets.

With KNAUF project, PAGroup were turning over about £108K up until the sustainability regulations were imposed – this has developed into £360K this year due to the reman. The efficiency has meant that customers are engaging their customers to deal with PMGRoup. Additionally, PAGroup provide blue waste wood bins to clients to isolate the returning 'core' pallets and solve the customers wood waste problem.
PAare moving into RFID chips to track pallets and to heavier pallets that will go though 10 'lives' of reman.

8.3 Responses Matrix

The responses matrix with all findings is attached as Appendix 10.

9.0 CONCLUSIONS

It is clear to me that in certain sectors, the solid conclusion is that reman is progressing strongly with assistance from advanced manufacturing methods. It is also clear that the pace of reman take-up is less than had been expected.

There is still a linear mindset, with FMCG commonly not being repairable, leading to an 'always-replace-with-new' – a distinct back-step in the linear to circular economy transition, and may lead to the idea that any reman items are 'sub-standard' and 'not-like-new'

There is a palpable suggestion of risk to investment in 'uncertain' markets for reman, countered by success stories such as CoreCentric. Much equipment is deemed 'unsuitable, however its acknowledged that 'design for ream' will suppress this. Cost is an issue, as are compliance costs and guarantees seen as risk items.

Often also, reman is invoked only at the request of the customer, who may have his own agenda points, centring over sustainability and green agenda reporting. My view is that those not clear about costs of reman are viewing it from 'outside' the fence – inside are convinced and use reman- the acid test.

Encouragingly, large, capital-heavy items are readily, and consistently already reman, as are machine tools, where the new technologies are helping place new edges onto worn sub-assemblies. But evidence exists of passing reman-suitable equipment into developing economies due to perceived uneconomic reman, perpetuating the linear mindset.

Cars and most other are disassembled and scrapped, excepting reman of classic vehicles – indeed 2 interviews indicate capital value drives the reman enthusiasm and business case. Eion Bailey believes the automotive industry is not on board with circularity, but this differs from my view of CoreCentric.

Unfortunately, the large UK public sector legislate against use of any reman – NHS ban on reman items in supply chain, the largest employer in Europe. On the positive side, respondents were reporting increase in turnover and recovery of potential lost contract using reman intelligently at PAGroup, leading to significant environmental credit.

10.0 RECOMMENDATION FOR FURTHER WORK

As recommendations for further work, I would suggest looking more at the sectors of industry where the areas of resistance put forward by Roy McFarlane originate, as the industries he works in have demonstrated satisfactory reman take-up from other reporting. Ideally, a larger sample would be better for a set of adjusted reman questions, with the knowledge of this report's findings, and the initial responses from my correspondents.

Additionally, the degree of Government and Regulatory assistance should be examined more fully, including the NHS current resistance to using any reman goods – as one of the largest 'corporates' in the UK economy, this is surprising and, demonstrative of some institutional resistance that we do pick up against reman as a principle.

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Zhao, G., Xiao, J., & Zhou, Q. (2021). Fatigue Models Based on Real Load Spectra and Corrected S-N Curve for Estimating the Residual Service Life of the Remanufactured Excavator Beam. *Metals (Basel)*, *11*(2), 365-. https://doi.org/10.3390/met11020365 NOW ADVANCED SCANNING, COMPUTATIONAL MODELLING AND METHEM MODELLING

Zhigang Jiang, Tingting Zhou, Hua Zhang, Yan Wang, Huajun Cao, Guangdong Tian, 2016 *Reliability and cost optimization for remanufacturing process planning*, Journal of Cleaner Production, Volume 135, 2016, Pages 1602-1610, (https://www.sciencedirect.com/science/article/pii/S0959652615016777)

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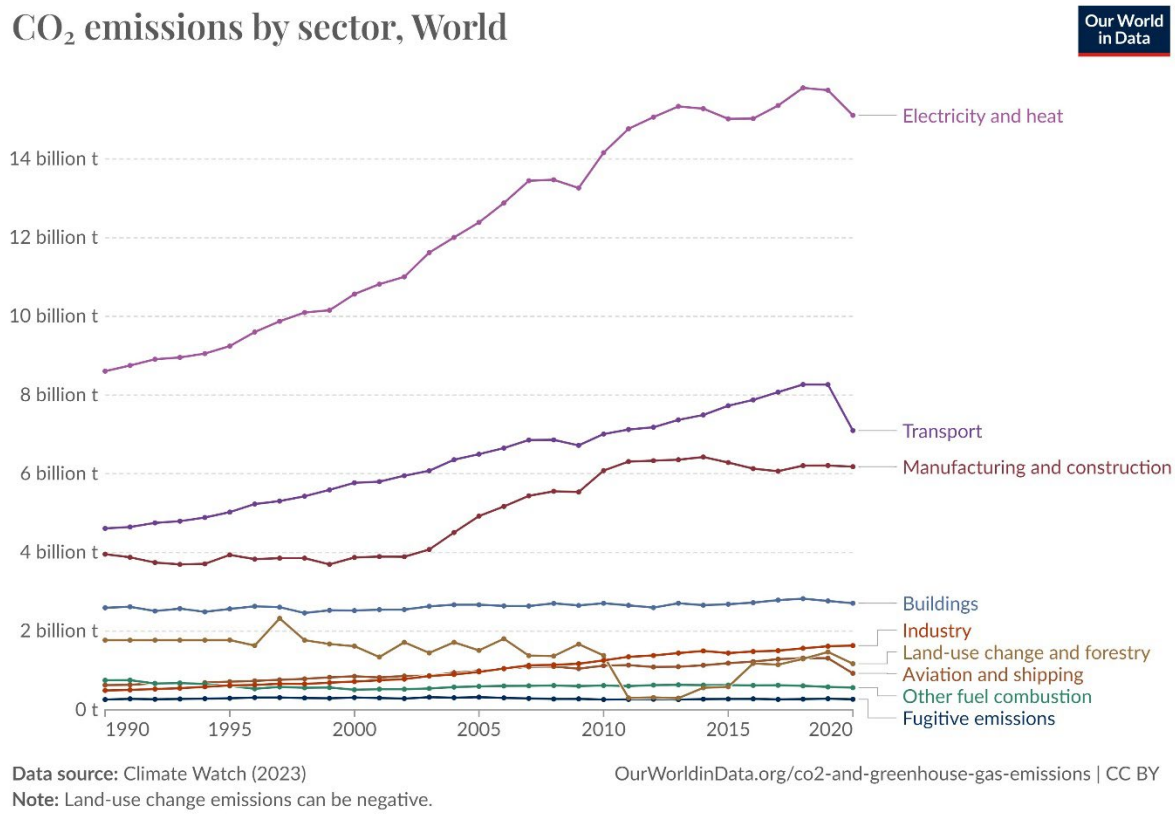
Zhigang Jiang, Tingting Zhou, Hua Zhang, Yan Wang, Huajun Cao, Guangdong Tian, 2016 *Reliability and cost optimization for remanufacturing process planning*, Journal of Cleaner Production, Volume 135, 2016, Pages 1602-1610, (https://www.sciencedirect.com/science/article/pii/S0959652615016777)

Appendices.

The appendices are attached by separate cover.

Appendix 1 – CO2 Emissions by Sector across the Globe.



H

annah Ritchie, Pablo Rosado and Max Roser (2020) - “Breakdown of carbon dioxide, methane and nitrous oxide emissions by sector” Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/emissions-by-sector' [Online Resource]Our World in Data :2024.

APPENDIX 2 : Blomsma and Brennan 2017

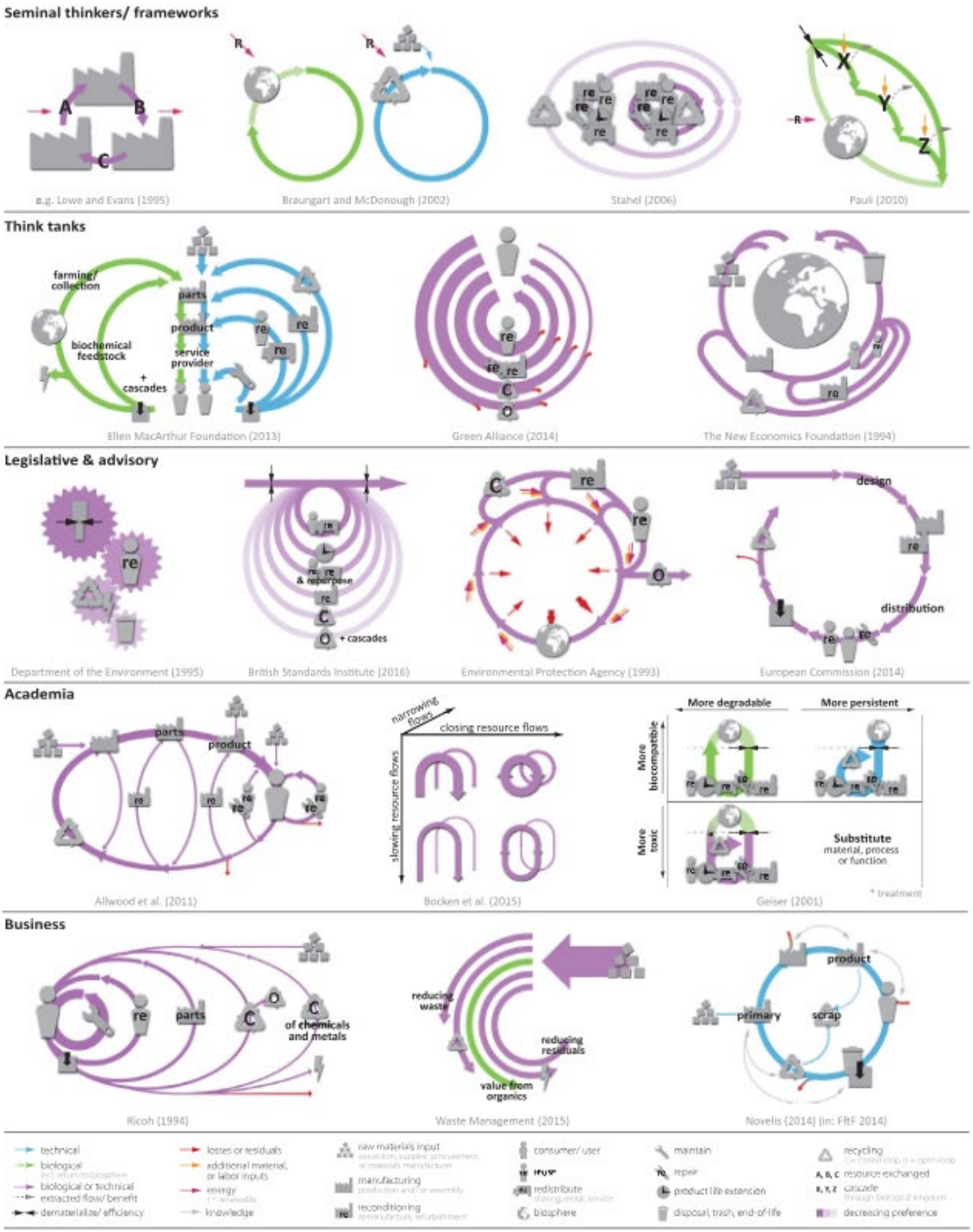


Figure 1 Overview of a selection of interpretations of waste and resource management frameworks. These illustrations purposefully lack some detail so as to draw attention to the underlying structure of these interpretations: that is, the major role that "circular" or resource life-extending strategies play as well as the preoccupation with organizing the relationship between strategies.

Appendix 3 European Commission – European Remanufacturing Network – WP 2.2 Remanufacturing Market Study – Final Report 20th October 2015.

The table below provides a summary of the findings by sector across the EU.

Sectors	Turnover (€bn)	Firms	Employm't ('000)	Core[2] ('000)	Intensity
Aerospace	12.4	1,000	71	5,160	11.5%
Automotive	7.4	2,363	43	27,286	1.1%
EEE	3.1	2,502	28	87,925	1.1%
Furniture	0.3	147	4	2,173	0.4%
HDOR	4.1	581	31	7,390	2.9%
Machinery	1.0	513	6	1,010	0.7%
Marine	0.1	7	1	83	0.3%
Medical equipment	1.0	60	7	1,005	2.8%
Rail	0.3	30	3	374	1.1%
Total	**29.8**	**7,204**	**192**	**132,405**	**1.9%**

[1] On-line survey, direct phoning, use of meta-studies and top-down analysis

[2] Core: a used part intended to become a remanufactured product

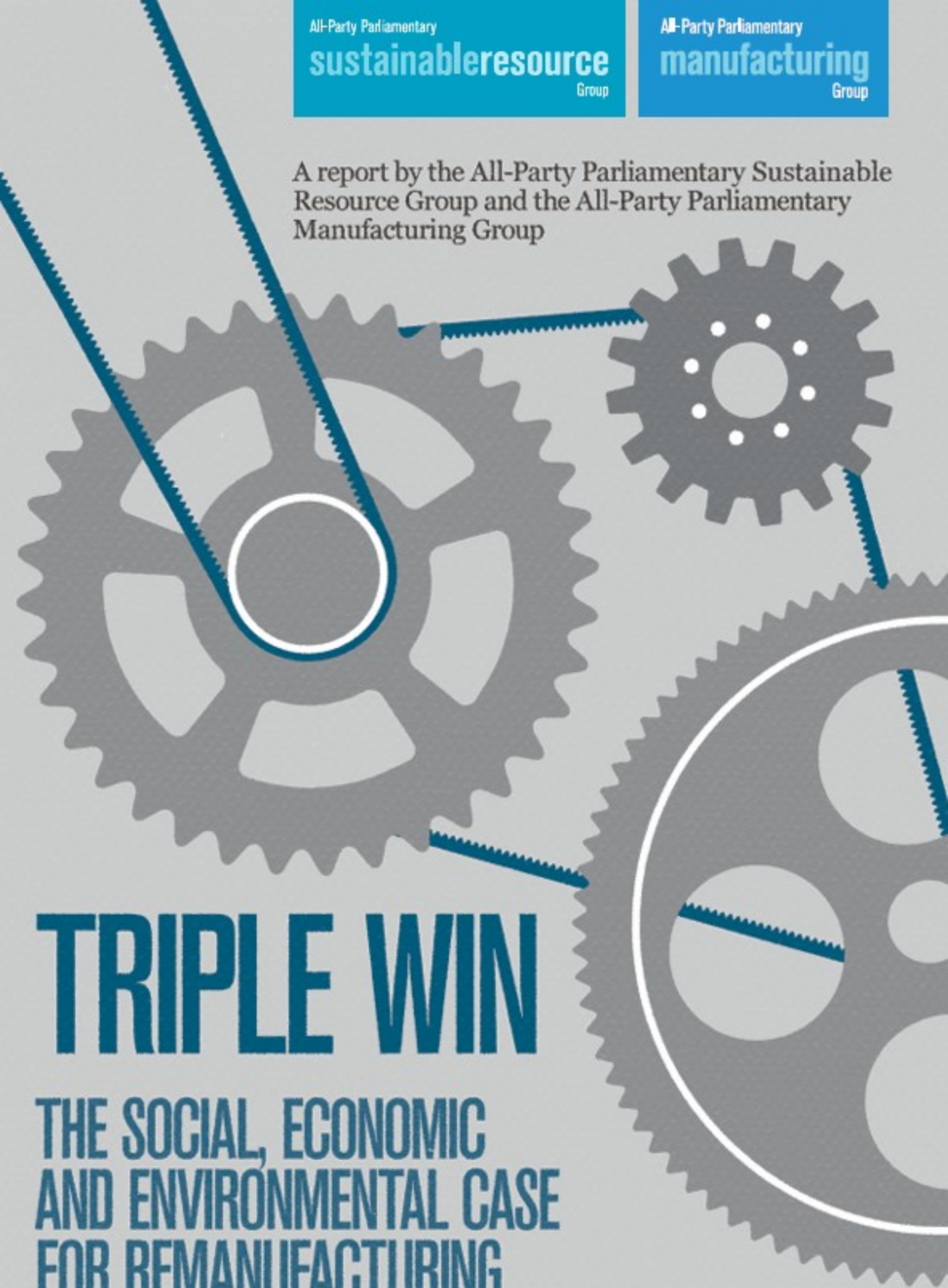
Turnover	Benelux[1]	Central[2]	Eastern[3]	France	Germany	Italy	Medi-terranean[4]	Nordic[5]	UK & Ireland	Total
Aerospace	389	399	513	2,311	3,814	1,127	816	368	2,698	12,436
Automotive	395	652	692	754	2,370	699	790	273	766	7,393
EEE	111	230	578	355	646	592	311	106	190	3,118
Furniture	10	16	52	24	66	66	23	18	34	310
HDOR	160	227	343	633	1,108	541	380	242	509	4,142
Machinery	44	45	81	108	336	199	70	53	90	1,026
Marine	11	2	15	3	11	8	13	5	6	76
Medical equipment	36	70	104	112	316	61	68	83	121	971
Rail	11	46	41	22	61	39	48	27	49	343
Total	1,167	1,687	2,420	4,322	8,728	3,333	2,519	1,173	4,463	29,813

Notes: [1] *Benelux: Belgium, Luxembourg, Netherlands*
[2] *Central (excluding Germany): Austria, Czech Republic, Slovenia*
[3] *Eastern: Bulgaria, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, Slovakia*
[4] *Mediterranean (excluding Italy): Croatia, Cyprus, Greece, Malta, Portugal, Spain*
[5] *Nordic: Denmark, Finland, Sweden*

All-Party Parliamentary sustainableresource Group

All-Party Parliamentary manufacturing Group

A report by the All-Party Parliamentary Sustainable Resource Group and the All-Party Parliamentary Manufacturing Group



TRIPLE WIN

THE SOCIAL, ECONOMIC AND ENVIRONMENTAL CASE FOR REMANUFACTURING

APPENDIX 5: 'Triple Win' – a short commentary.

Ref APPSRG/APPMG Report Triple Win - The Social, Economic and Environmental Case for Remanufacturing (see Appendix for background on the APPSRG/APPMG)

Appendix material: **All-Party Parliamentary Sustainable Resource Group** The APSRG is the leading forum informing the debate between parliamentarians, business leaders and the sustainable resource community on the crucial policy issues affecting sustainable resource management in the UK. Its mission is to provide an objective platform for effective communication between policy-makers, businesses and organisations with an interest in the sustainable resource management agenda and to raise awareness of sustainable resource issues within Parliament. All-Party Parliamentary Manufacturing Group The All-Party Parliamentary Manufacturing Group (APMG) is a cross-party coalition of Parliamentarians and manufacturing industry organisations that works to develop new industrial policy ideas, critique existing government decision-making around manufacturing, communicate within Parliament the importance of a well-balanced productive economy, and help the manufacturing community better engage with the policy process. With renewed political focus on the need to rebalance the UK economy and begin the 'march of the makers', the APMG seeks to ensure that policies and programmes to support the manufacturing sector achieve consensus from all parties, and across industry.

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Y Drindod Dewi Sant
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Dear Manufacturer/Supplier/Consultant: 1st September 2024

As part of my MSc in Advanced Manufacturing at UWTSD, my dissertation centers on remanufacturing and how it has been changed by rapidly developing data handling, enhanced design methods, analysis tools and new manufacturing techniques. These changes are made possible from recent technical and data advances, generally termed 'Industry 4.0'.

I am looking for pure manufacturing or service companies who utilize remanufacture within their product cycle or even know of it and don't use it. I would be interested in having a brief chat with them, probably on zoom or teams, but in person if convenient, to aid my research in this field.

I hope you can contact me or let me know of any manufacturers or service companies who fit this description – the general survey questions are listed below – they could lead to other questions, or helpful comment, of course.

UK Manufacturing and the impact of recent advances in data handling, design methods, AI, new materials and robotic methods on re-manufacture* of items and assemblies.

**Remanufacture can be defined as a process in which good quality end-of-life components or assemblies are fully examined and re-worked to an original condition and used to produce new products with a new warranty.*

1. Are you aware of, and if so, how do you perceive re-manufacturing as a technique?
2. Would your customers consider re-manufacturing (not refurbishment) as a way to reduce their costs?
3. Do you use re-manufacturing within your own company operations and skill set?
4. Do you use suppliers who supply re-manufactured items to your business?
5. Do you use the services of companies who re-manufacture your own tools or assemblies for you?
6. How would you say re-manufacturing has advanced within the industry sectors you occupy?
7. Are there recent technological advances that might encourage you to use or consider re-manufacture?
8. What would you see are the main barriers to your sectors using re-manufacture ?
9. Are there any legislatory or Government policy changes that would encourage you and others to use re-manufacture within your sector, or the suppliers you deal with?
10. Are you aware of any negative examples of where re-manufacture has resulted in an issue or failure?

Many thanks again, I look forward to hearing from you when convenient**, if possible by 30th September.**

Simon Shuker Email: 2112202@student.uwtsd.ac.uk , & simon@hafrenousque.com 07833 207643

Reman Meeting Notes

Autentica Car Parts

Representative: Irma Gilbert irma@autenticaparts.com

Notes made by: Simon Shuker

Date: 12th January 2024, phone discussion.

Re: Simon Shuker - Remanufacturing Survey and Related Questions

Meeting Notes

Irma introduced autentica – at the time of the discussion they are an early stage start up producing 3D printing of car parts, current and classic, including Porsche, Cadillac, Volvo. Their aims are to slimline the remanufacturing process by providing scarce or otherwise prohibitively expensive parts to exacting geometry that enable remanufacturers and vehicle restorers to complete reman builds of vehicles which are currently not serviceable because of EOL parts that are not readily available.

The ability of advaned manufacturing technology- in their case mainly additive manufacturing/3D printing- enables them to provide a part derived from an OEM original or from original manufacturing information and designs/drawing data. This is achieved by a point-cloud scan of the item, which proceeds to design, and then 3D printing in the correct material, or by direct data trasfer into the CAD design of the original design information and geometry.

The part is then post-processed by milling or other 'subtractive manufacturing' to provide the required part geometry and finish. The 3D printing can be either at autentica, or by file transfer facilitated with NFT security, the item can be 3D printed by the customer remotely at his works, using a one-time secure code. NFT is a data file, stored on a blockchain databank, which is sold as the access to the 3D print file. The NFT is associated with the 3D part, and it confers licensing rights to produce the part once only and use the asset for the specified purpose.

Files have been sent and parts produced remotely in Spain, Singapore, Malta, Brazil, and Chile.

Many areas of the work they are doing are very recent development and some under live development as the offering proceeds. Irma notes the concept would not have been possible as a package until the last 12 months or so. These assembled techs needed to combine to allow the overall process - include the scanning and design analysis, the selection of 3D printing materials, the NFT, and the availability of the 3D printing equipment at autentic, and at the remote locvations the NFT tokens are sent to.

Iram fimrly believes the autentica business model and performance so far is the key to a wider use of reman in reducing company costs and timescales to bring EOL vehicles bkack to use, redicing carbon usage of this process, reducing carbon in transportation methods of the parts, and in providing reasons for upskilling within the customers they are dealing with as customers.

-end-

Simon Shuker - Dissertation October

Remanufacturing Survey

Remanufacturing question
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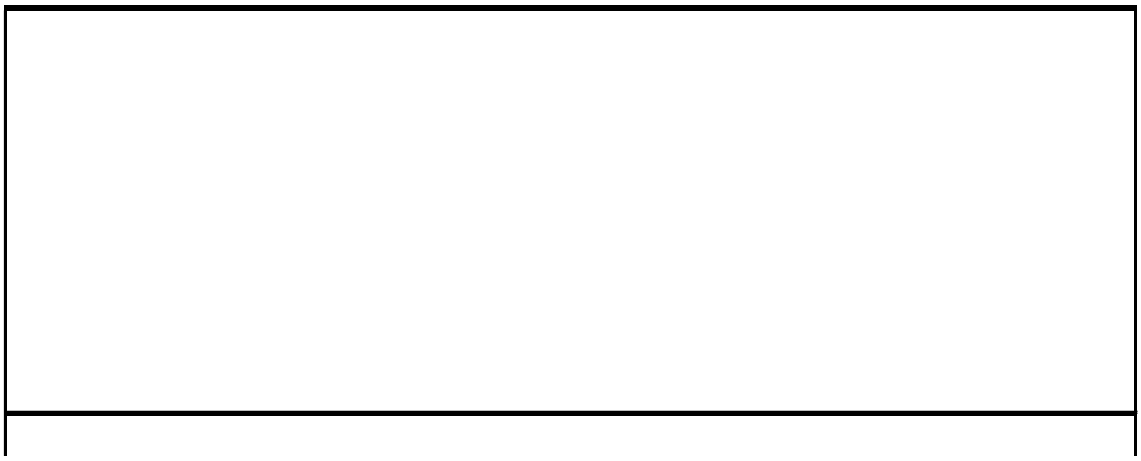
Other comments

2024

y Findings Matrix

Column1



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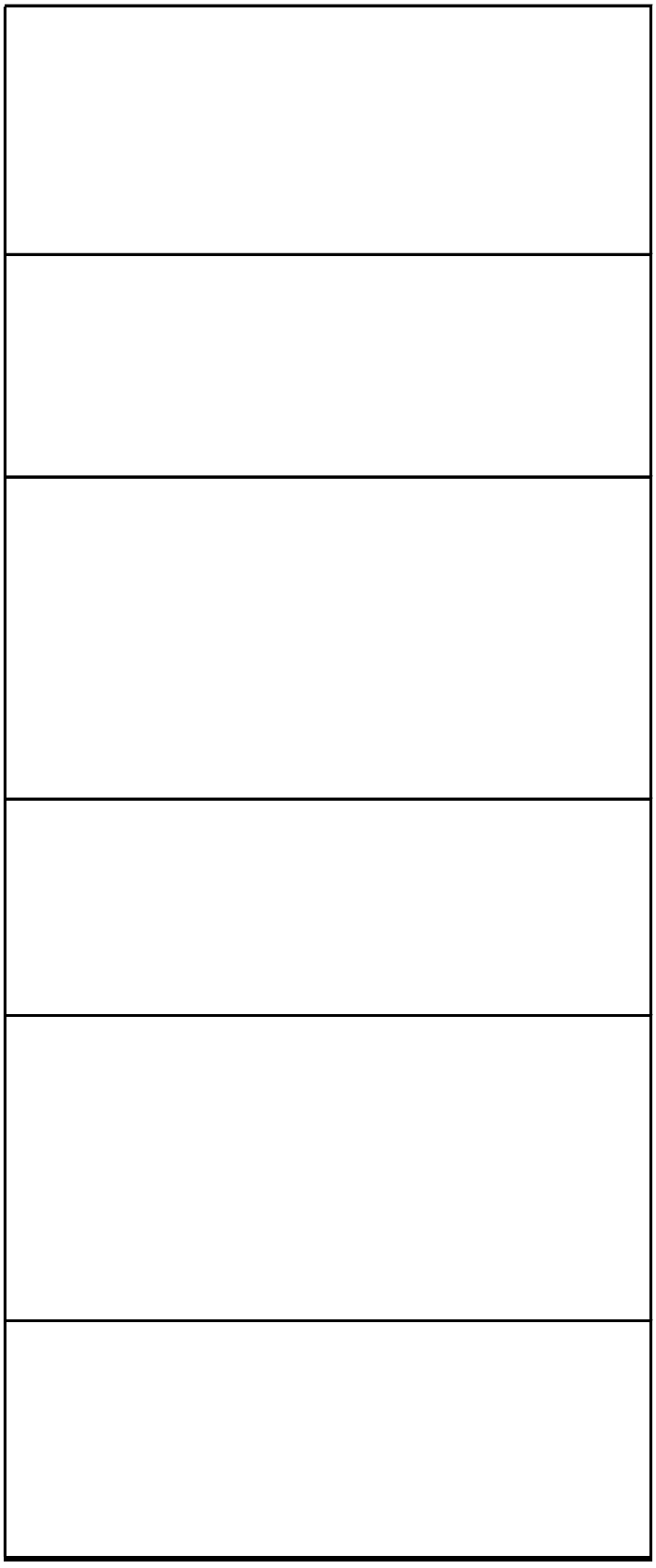

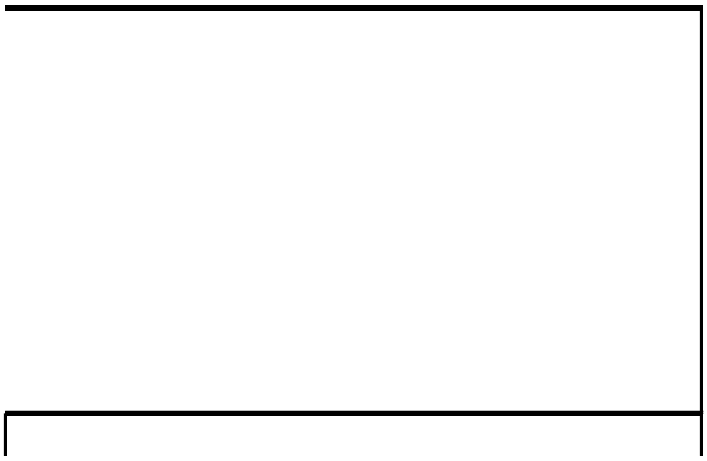

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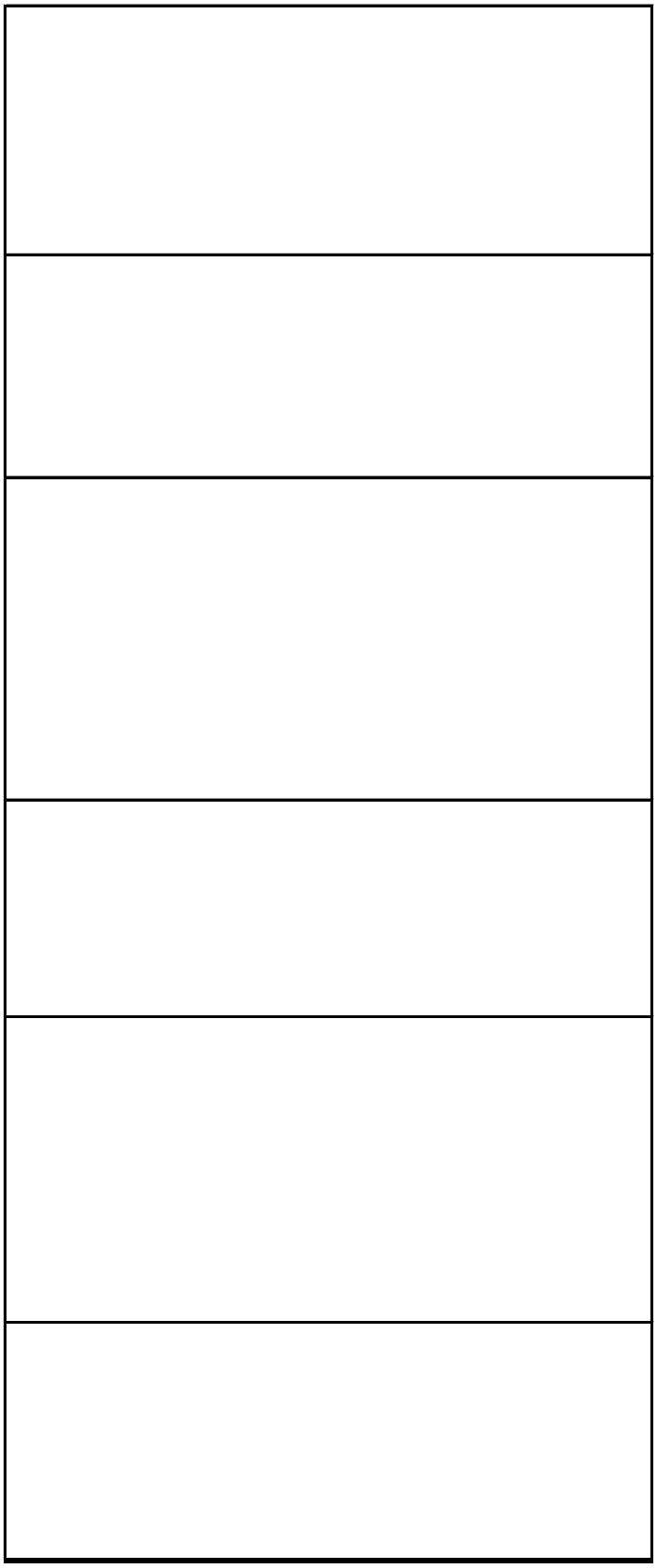

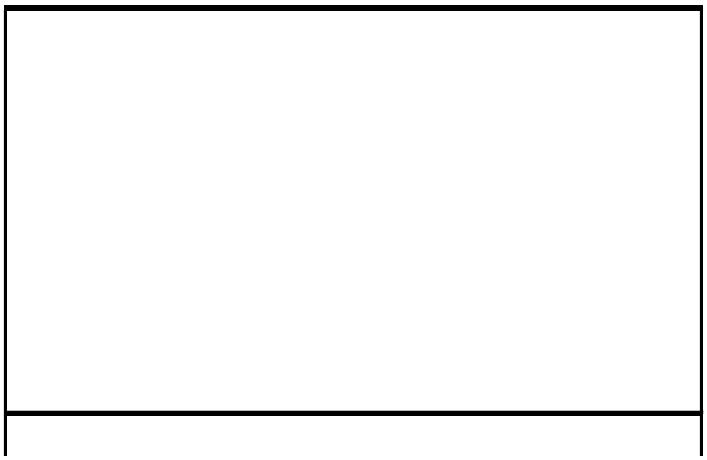

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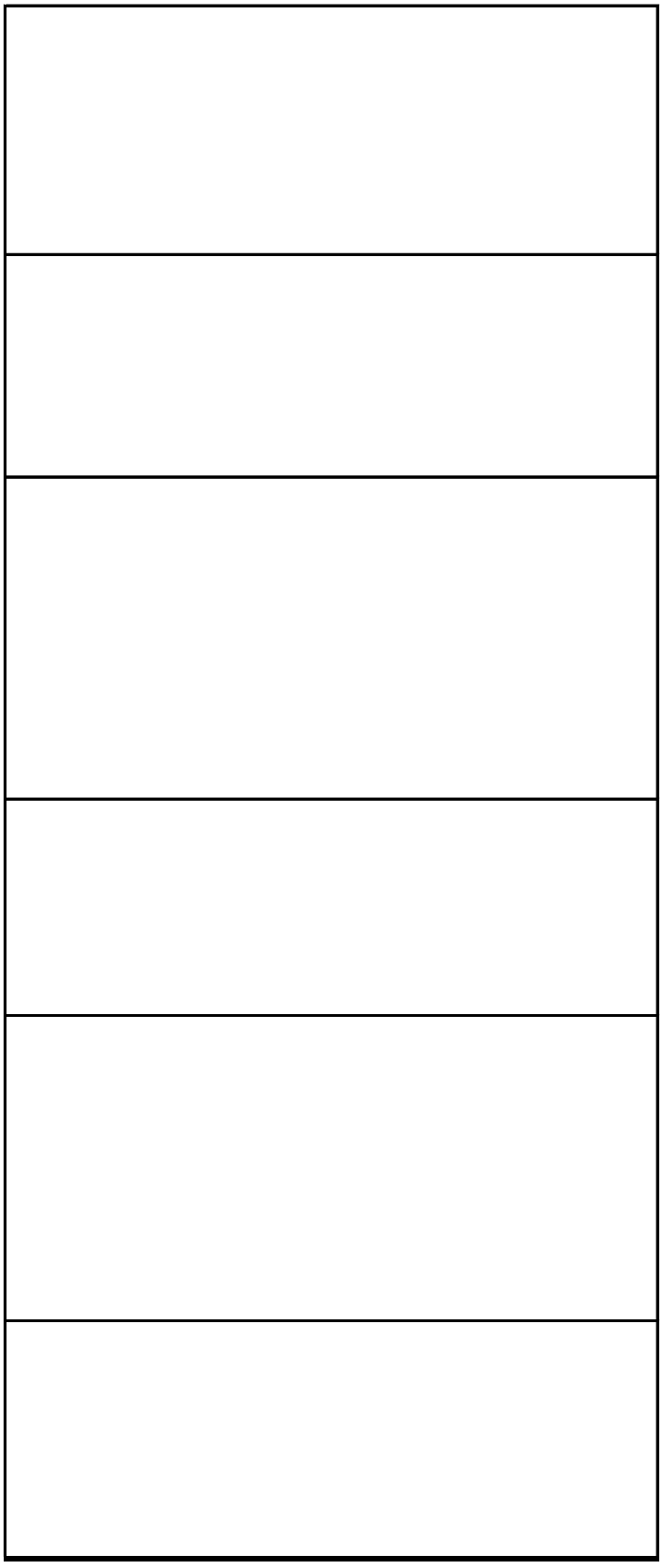

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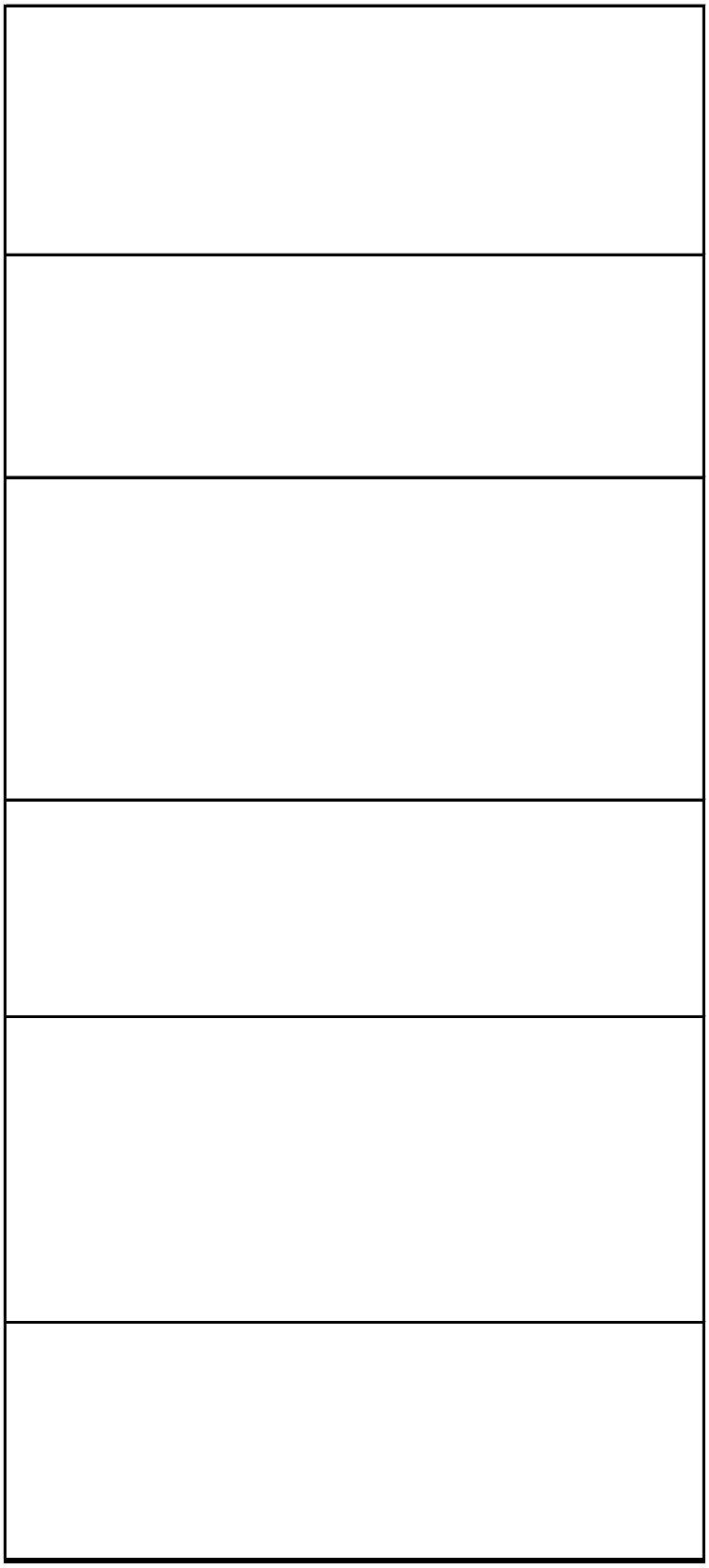

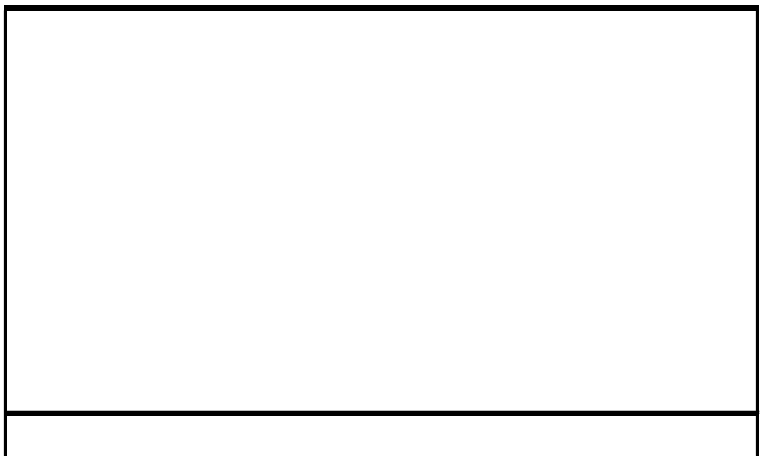

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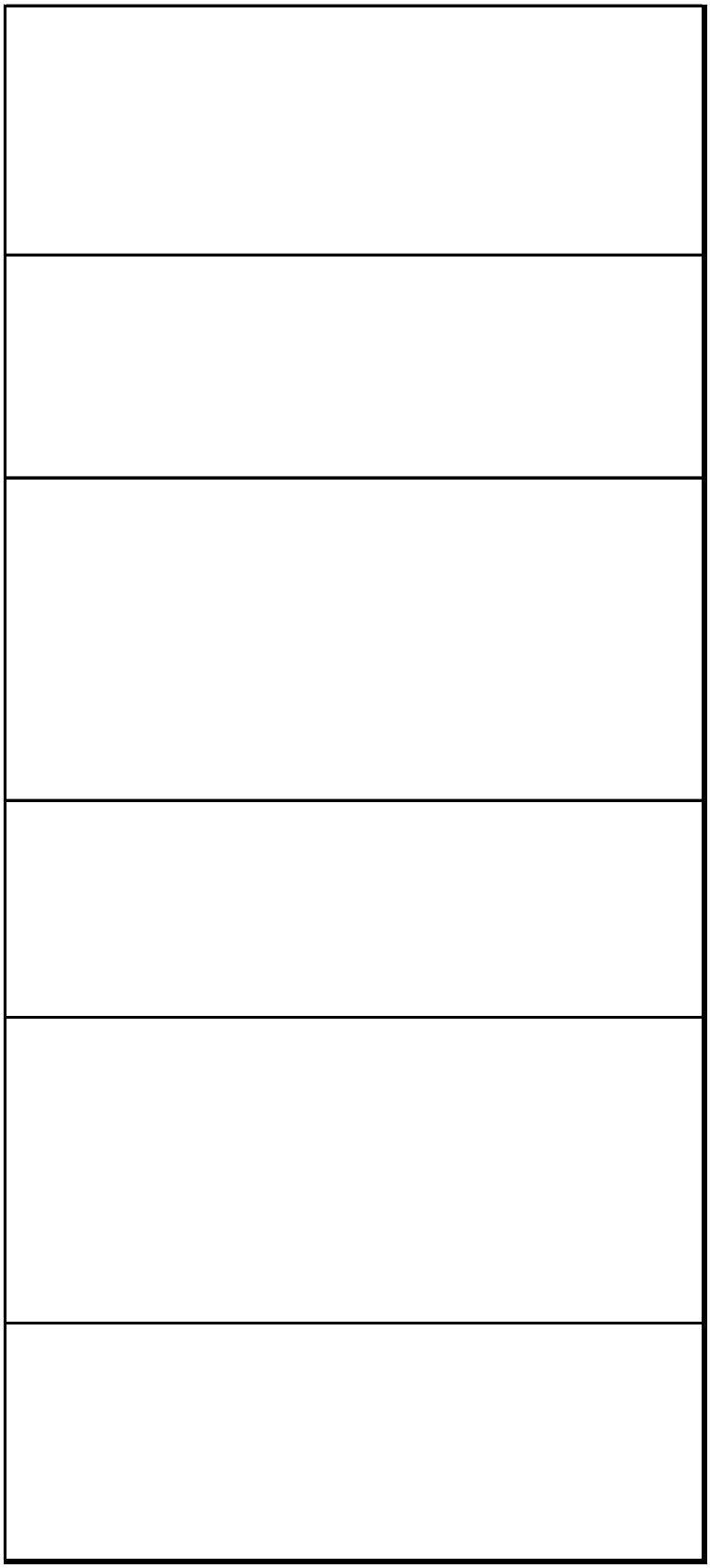

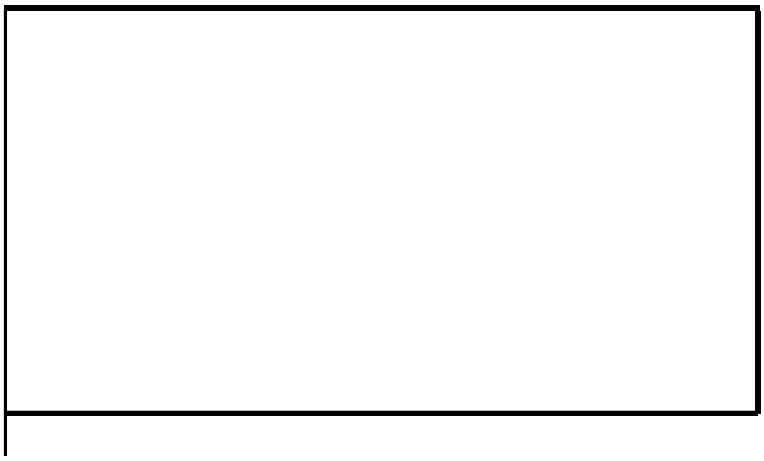

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Simon Shuker - Dissertation October

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Other comments
continued.....
continued.....

2024

y Findings Matrix

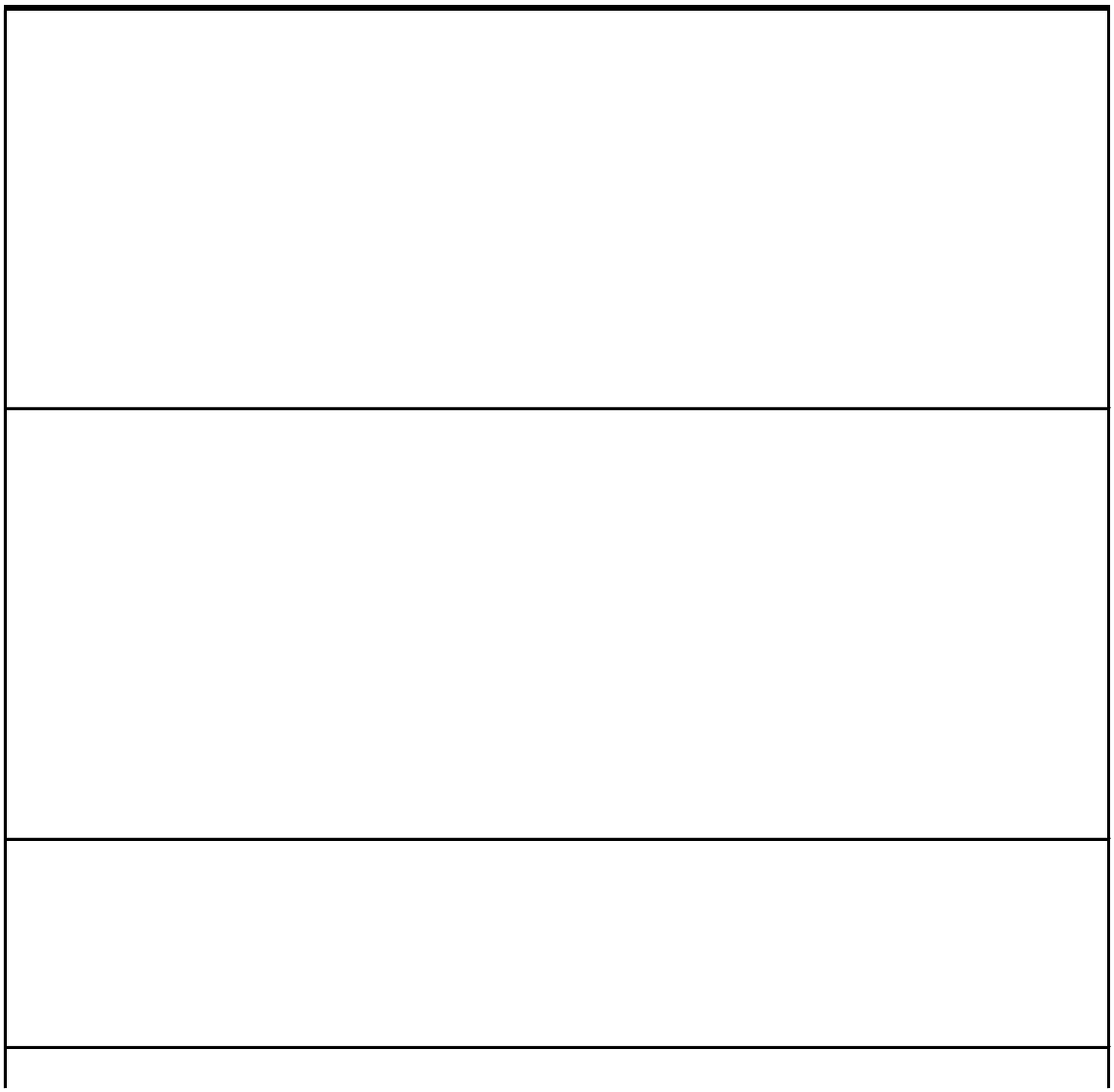
Roy McFarlane Total Productivity (first person written responses)
Yes, I m aware of remanufacturing as a technique, Most often commercial equipment is unsuitable for remanufacturing
No, typically remanufacturing is more expensive (due to dismantlement costs)No, customers want lengthy Guarantees and Warrantees and typically don’t trust reuse of components
No, the extent is refurbishment and reuse of structural elements only
No, the complexity of parts means that it is too costly to remanufacture components and be competitive.

No, the extent is refurbishment
No, refurbishment with reuse of certain components is routine but not remanufacturing.
No, the introduction of carbon fiber and composite materials makes reuse and remanufacture unworkable. The majority of components are complex assemblies (motors, circuit boards, cables, safety switchgear and solenoid actuators or other mixed material components)
Cost Complexity of disassembly and remaking Validity and compliance of legacy materials
No, the Machinery Directive and associated safety and warrantee liabilities remain the most significant regulatory barriers for remanufacture.
Not specifically. I am aware of several European machinery manufacturers that have explored remanufacture and none have found it viable from a cost and compliance perspective.

CTI (also in Italy), Bhargab (India), Coveyor (Bristol), Gemma lighting (Fareham), Herma printers (Germany) and Flexlink (Intenational); all state that they may want to but are unable to guarantee products that reuse parts, and it is much more expensive to reprocess materials to an "original supply" standard.
Bosch Packaging (Netherlands) reuse structural components only, as part of a buy back scheme, but generally only refurbish on the request of a customer – in batches to improve cost effectiveness.My contact stated that the refurbishments with high percentages of reused parts, are typically at the request of customers like Unilever.
My contact stated that the refurbishments with high percentages of reused parts, are typically at the request of customers like Unilever.

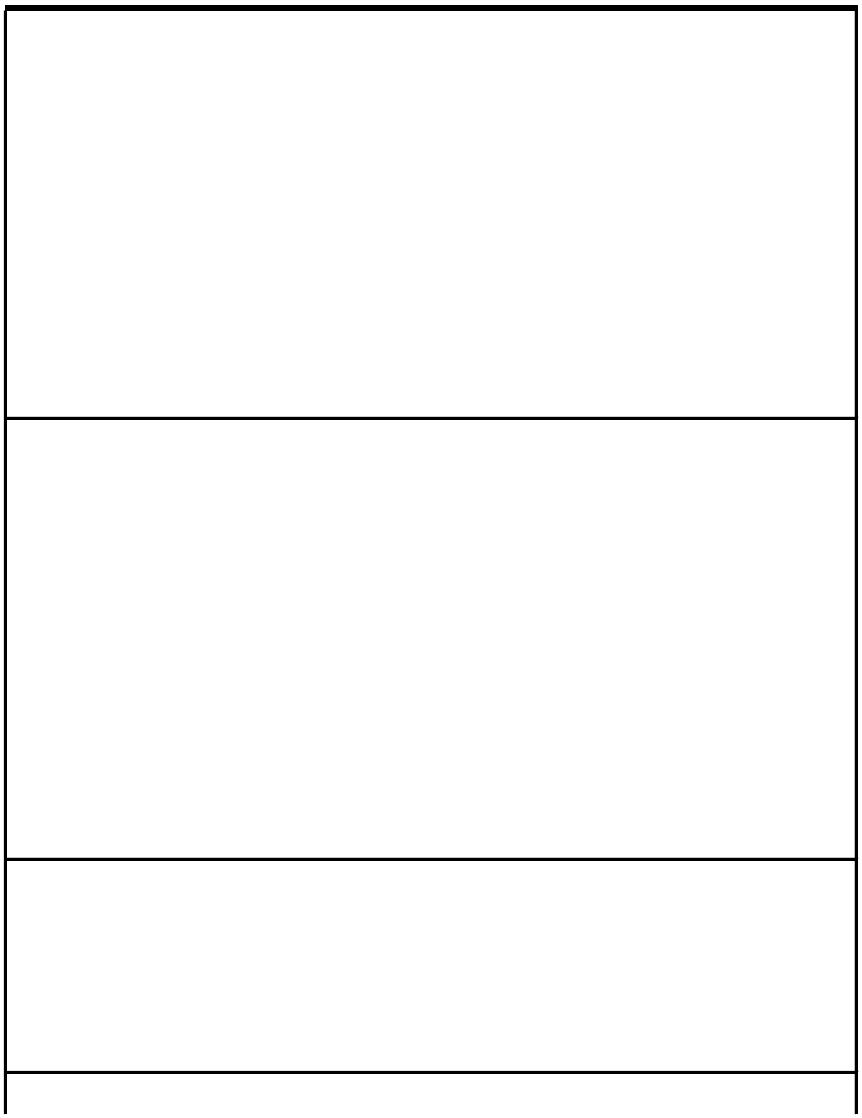
Irma Gilbert Autentica
Yes
Yes
Yes
Yes

Yes - items printed elsewhere using our coding.
Yes
Yes, entirely,.
Technology adoption and costs
No
No



Chris Probert Aber Instruments
Yes
No
No
No

No
More Detailed analysis
No
Verification of performance and clean condition.
No
No.

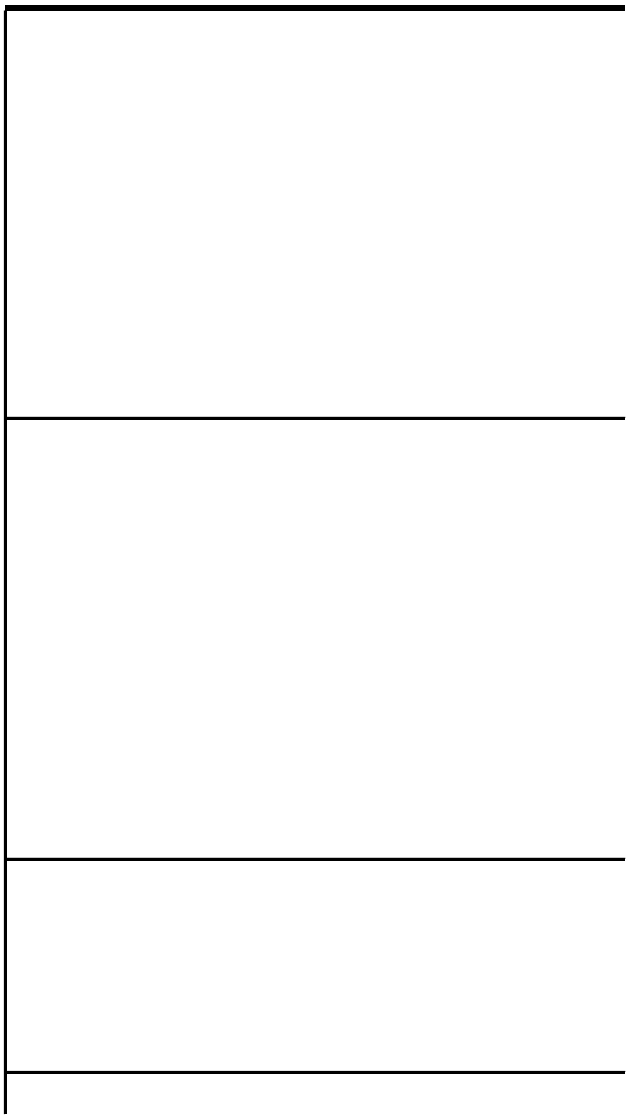


Eoin Bailey Celsa UK	Jon Peck Electric Classic Cars
Yes	**Yes, the re-making of original goods in verified condition.**
Yes	**Yes**
Yes	**Yes**
Yes	**Yes**

No	**Yes**
re-use and re-purposing of buildings	**New manufacture methods,**
N/A	**N/A**
None	**Cost**
EOL vehicle and product legislatation.	**No**
No	**No**

Rhys Jones, P A Group.
Yes
Yes
Yes
Yes

Yes
Yes
Yes, ID chips for recording product flow
Cost of uprating equipment.
No
No



THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 95 thereof,

Having regard to the proposal from the Commission [1],

Having regard to the opinion of the European Economic and Social Committee [2],

Acting in accordance with the procedure laid down in Article 251 of the Treaty [3],

Whereas:

(1) Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery [4] codified Directive 89/392/EEC [5]. Now that new substantial amendments are being made to Directive 98/37/EC, it is desirable, in order to clarify matters, that that Directive should be recast.

(2) The machinery sector is an important part of the engineering industry and is one of the industrial mainstays of the Community economy. The social cost of the large number of accidents caused directly by the use of machinery can be reduced by inherently safe design and construction of machinery and by proper installation and maintenance.

(3) Member States are responsible for ensuring the health and safety on their territory of persons, in particular of workers and consumers and, where appropriate, of domestic animals and goods, notably in relation to the risks arising out of the use of machinery.

(4) In order to ensure legal certainty for users, the scope of this Directive and the concepts relating to its application should be defined as precisely as possible.

(5) The Member States' mandatory provisions governing construction site hoists intended for lifting persons or persons and goods, which are often supplemented by de facto compulsory technical specifications and/or by voluntary standards, do not necessarily lead to different levels of health and safety but, because of their disparities, do nevertheless constitute barriers to trade within the Community. Moreover, the national systems for the conformity assessment and certification of these machines diverge considerably. It is therefore desirable not to exclude from the scope of this Directive construction site hoists intended for lifting persons or persons and goods.

(6) It is appropriate to exclude from the scope of this Directive weapons, including firearms, that are subject to Council Directive 91/477/EEC of 18 June 1991 on control of the acquisition and possession of weapons [6]; the exclusion of firearms should not apply to portable cartridge-operated fixing and other impact machinery designed for industrial or technical purposes only. It is necessary to provide for transitional arrangements enabling Member States to authorise the placing on the market and putting into service of such machinery manufactured in accordance with national provisions in force upon adoption of this Directive, including those implementing the Convention of 1 July 1969 on the Reciprocal Recognition of Proofmarks on Small Arms. Such transitional arrangements will also enable the European standardisation organisations to draft standards ensuring the safety level based on the state of the art.

(7) This Directive does not apply to the lifting of persons by means of machines not designed for the lifting of persons. However, this does not affect the right of Member States to take national measures, in accordance with the Treaty, with respect to such machines, with a view to implementing Council Directive 89/655/EEC of 30 November 1989 concerning the minimum safety and health requirements for the use of work equipment by workers at work (second individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) [7].

(8)In relation to agricultural and forestry tractors, the provisions of this Directive concerning the risks currently not covered by Directive 2003/37/EC of the European Parliament and of the Council of 26 May 2003 on type-approval of agricultural or forestry tractors, their trailers and interchangeable towed machinery, together with their systems, components and separate technical units [8] should no longer apply when such risks are covered by Directive 2003/37/EC.

(9) Market surveillance is an essential instrument inasmuch as it ensures the proper and uniform application of Directives. It is therefore appropriate to put in place the legal framework within which market surveillance can proceed harmoniously.

(10)Member States are responsible for ensuring that this Directive is effectively enforced on their territory and that the safety of the machinery concerned is, as far as possible, improved in accordance with its provisions. Member States should ensure their capacity to carry out effective market surveillance, taking account of guidelines developed by the Commission, in order to achieve the proper and uniform application of this Directive.

(11)In the context of market surveillance, a clear distinction should be established between the disputing of a harmonised standard conferring a presumption of conformity on machinery and the safeguard clause relating to machinery.

(12)The putting into service of machinery within the meaning of this Directive can relate only to the use of the machinery itself for its intended purpose or for a purpose which can reasonably be foreseen. This does not preclude the laying down of conditions of use external to the machinery, provided that it is not thereby modified in a way not specified in this Directive.

(13)It is also necessary to provide for an adequate mechanism allowing for the adoption of specific measures at Community level requiring Member States to prohibit or restrict the placing on the market of certain types of machinery presenting the same risks to the health and safety of persons either due to shortcomings in the relevant harmonised standard(s) or by virtue of their technical characteristics, or to make such machinery subject to special conditions. In order to ensure the appropriate assessment of the need for such measures, they should be taken by the Commission, assisted by a committee, in the light of consultations with the Member States and other interested parties. Since such measures are not directly applicable to economic operators, Member States should take all necessary measures for their implementation.

(14)The essential health and safety requirements should be satisfied in order to ensure that machinery is safe; these requirements should be applied with discernment to take account of the state of the art at the time of construction and of technical and economic requirements.

(15)Where the machinery may be used by a consumer, that is to say, a non-professional operator, the manufacturer should take account of this in the design and construction. The same applies where a machine is normally used to provide a service to a consumer.

(16)Although the requirements of this Directive do not apply to partly completed machinery in their entirety, it is nevertheless important that the free movement of such machinery be guaranteed by means of a specific procedure.

(17)For trade fairs, exhibitions and such like, it should be possible to exhibit machinery which does not satisfy the requirements of this Directive. However, interested parties should be properly informed that the machinery does not conform and cannot be purchased in that condition.

(18)This Directive defines only the essential health and safety requirements of general application, supplemented by a number of more specific requirements for certain categories of machinery. In order to help manufacturers to prove conformity to these essential requirements, and to allow inspection of conformity to the essential requirements, it is desirable to have standards that are harmonised at

Community level for the prevention of risks arising out of the design and construction of machinery. These standards are drawn up by private-law bodies and should retain their non-binding status.

(19)In view of the nature of the risks involved in the use of machinery covered by this Directive, procedures for assessing conformity to the essential health and safety requirements should be established. These procedures should be devised in the light of the extent of the danger inherent in such machinery. Consequently, each category of machinery should have its appropriate procedure in conformity with Council Decision 93/465/EEC of 22 July 1993 concerning the modules for the various phases of the conformity assessment procedures and the rules for the affixing and use of the CE conformity marking, which are intended to be used in the technical harmonisation directives ([9]), taking account of the nature of the verification required for such machinery.

(20)Manufacturers should retain full responsibility for certifying the conformity of their machinery to the provisions of this Directive. Nevertheless, for certain types of machinery having a higher risk factor, a stricter certification procedure is desirable.

(21)The CE marking should be fully recognised as being the only marking which guarantees that machinery conforms to the requirements of this Directive. All other markings which are likely to mislead third parties as to the meaning or the form of the CE marking, or both, should be prohibited.

(22)In order to ensure the same quality for the CE marking and the manufacturer's mark, it is important that they be affixed according to the same techniques. In order to avoid confusion between any CE markings which might appear on certain components and the CE marking corresponding to the machinery, it is important that the latter marking be affixed alongside the name of the person who has taken responsibility for it, namely the manufacturer or his authorised representative.

(23)The manufacturer or his authorised representative should also ensure that a risk assessment is carried out for the machinery which he wishes to place on the market. For this purpose, he should determine which are the essential health and safety requirements applicable to his machinery and in respect of which he must take measures.

(24)It is essential that, before drawing up the EC declaration of conformity, the manufacturer or his authorised representative established in the Community should prepare a technical construction file. However, it is not essential that all documentation should be permanently available in material form, but it must be possible to make it available on request. It need not include detailed plans of subassemblies used for the manufacture of machinery, unless knowledge of such plans is essential in order to ascertain conformity with the essential health and safety requirements.

(25)The addressees of any decision taken under this Directive should be informed of the reasons for such a decision and of the legal remedies open to them.

(26)Member States should provide for penalties applicable to infringements of the provisions of this Directive. Those penalties should be effective, proportionate and dissuasive.

(27)The application of this Directive to a number of machines intended for lifting persons requires a better delimitation of the products covered by this Directive with respect to those covered by Directive 95/16/EC of the European Parliament and of the Council of 29 June 1995 on the approximation of the laws of the Member States relating to lifts ([10]). A redefinition of the scope of the latter Directive is thus deemed necessary. Directive 95/16/EC should therefore be amended accordingly.

(28)Since the objective of this Directive, namely, to lay down the essential health and safety requirements in relation to design and manufacture in order to improve the safety of machinery placed on the market, cannot be sufficiently achieved by the Member States and can be better achieved at Community level, the Community may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5

of the Treaty. In accordance with the principle of proportionality, as set out in that Article, this Directive does not go beyond what is necessary in order to achieve that objective.

(29) In accordance with point 34 of the Interinstitutional Agreement on better law-making [11], Member States are encouraged to draw up, for themselves and in the interests of the Community, their own tables illustrating, as far as possible, the correlation between this Directive and the transposition measures, and to make them public.

(30) The measures necessary for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission [12],

HAS ADOPTED THIS DIRECTIVE:

Article 1

Scope

1. This Directive applies to the following products:

(a) machinery;

(b) interchangeable equipment;

(c) safety components;

(d) lifting accessories;

(e) chains, ropes and webbing;

(f) removable mechanical transmission devices;

(g) partly completed machinery.

2. The following are excluded from the scope of this Directive:

(a) safety components intended to be used as spare parts to replace identical components and supplied by the manufacturer of the original machinery;

(b) specific equipment for use in fairgrounds and/or amusement parks;

(c) machinery specially designed or put into service for nuclear purposes which, in the event of failure, may result in an emission of radioactivity;

(d) weapons, including firearms;

(e) the following means of transport:

— agricultural and forestry tractors for the risks covered by Directive 2003/37/EC, with the exclusion of machinery mounted on these vehicles,

— motor vehicles and their trailers covered by Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers [13], with the exclusion of machinery mounted on these vehicles,

— vehicles covered by Directive 2002/24/EC of the European Parliament and of the Council of 18 March 2002 relating to the type-approval of two or three-wheel motor vehicles [14], with the exclusion of machinery mounted on these vehicles,

— motor vehicles exclusively intended for competition, and

—means of transport by air, on water and on rail networks with the exclusion of machinery mounted on these means of transport;

(f) seagoing vessels and mobile offshore units and machinery installed on board such vessels and/or units;

(g) machinery specially designed and constructed for military or police purposes;

(h) machinery specially designed and constructed for research purposes for temporary use in laboratories;

(i) mine winding gear;

(j) machinery intended to move performers during artistic performances;

(k) electrical and electronic products falling within the following areas, insofar as they are covered by Council Directive 73/23/EEC of 19 February 1973 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits [15]:

— household appliances intended for domestic use,

— audio and video equipment,

— information technology equipment,

— ordinary office machinery,

— low-voltage switchgear and control gear,

— electric motors;

(l) the following types of high-voltage electrical equipment:

— switch gear and control gear,

— transformers.

Article 2

Definitions

For the purposes of this Directive, ‘machinery’ designates the products listed in Article 1(1)(a) to (f).

The following definitions shall apply:

(a) ‘machinery’ means:

—an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application,

—an assembly referred to in the first indent, missing only the components to connect it on site or to sources of energy and motion,

—an assembly referred to in the first and second indents, ready to be installed and able to function as it stands only if mounted on a means of transport, or installed in a building or a structure,

—assemblies of machinery referred to in the first, second and third indents or partly completed machinery referred to in point (g) which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole,

—an assembly of linked parts or components, at least one of which moves and which are joined together, intended for lifting loads and whose only power source is directly applied human effort;

(b)‘interchangeable equipment’ means a device which, after the putting into service of machinery or of a tractor, is assembled with that machinery or tractor by the operator himself in order to change its function or attribute a new function, in so far as this equipment is not a tool;

(c)‘safety component’ means a component:

— which serves to fulfil a safety function,

— which is independently placed on the market,

— the failure and/or malfunction of which endangers the safety of persons, and

—which is not necessary in order for the machinery to function, or for which normal components may be substituted in order for the machinery to function.

An indicative list of safety components is set out in Annex V, which may be updated in accordance with Article 8(1)(a);

(d)‘lifting accessory’ means a component or equipment not attached to the lifting machinery, allowing the load to be held, which is placed between the machinery and the load or on the load itself, or which is intended to constitute an integral part of the load and which is independently placed on the market; slings and their components are also regarded as lifting accessories;

(e)‘chains, ropes and webbing’ means chains, ropes and webbing designed and constructed for lifting purposes as part of lifting machinery or lifting accessories;

(f)‘removable mechanical transmission device’ means a removable component for transmitting power between self-propelled machinery or a tractor and another machine by joining them at the first fixed bearing. When it is placed on the market with the guard it shall be regarded as one product;

(g)‘partly completed machinery’ means an assembly which is almost machinery but which cannot in itself perform a specific application. A drive system is partly completed machinery. Partly completed machinery is only intended to be incorporated into or assembled with other machinery or other partly completed machinery or equipment, thereby forming machinery to which this Directive applies;

(h)‘placing on the market’ means making available for the first time in the Community machinery or partly completed machinery with a view to distribution or use, whether for reward or free of charge;

(i)‘manufacturer’ means any natural or legal person who designs and/or manufactures machinery or partly completed machinery covered by this Directive and is responsible for the conformity of the machinery or the partly completed machinery with this Directive with a view to its being placed on the market, under his own name or trademark or for his own use. In the absence of a manufacturer as defined above, any natural or legal person who places on the market or puts into service machinery or partly completed machinery covered by this Directive shall be considered a manufacturer;

(j)‘authorised representative’ means any natural or legal person established in the Community who has received a written mandate from the manufacturer to perform on his behalf all or part of the obligations and formalities connected with this Directive;

(k)‘putting into service’ means the first use, for its intended purpose, in the Community, of machinery covered by this Directive;

(l)‘harmonised standard’ means a non-binding technical specification adopted by a standardisation body, namely the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC) or the European Telecommunications Standards Institute (ETSI), on the basis of a remit issued by the Commission in accordance with the procedures laid down in Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of

information in the field of technical standards and regulations and of rules on Information Society services ([16]).

Article 3

Specific Directives

Where, for machinery, the hazards referred to in Annex I are wholly or partly covered more specifically by other Community Directives, this Directive shall not apply, or shall cease to apply, to that machinery in respect of such hazards from the date of implementation of those other Directives.

Article 4

Market surveillance

1. Member States shall take all appropriate measures to ensure that machinery may be placed on the market and/or put into service only if it satisfies the relevant provisions of this Directive and does not endanger the health and safety of persons and, where appropriate, domestic animals or property, when properly installed and maintained and used for its intended purpose or under conditions which can reasonably be foreseen.

2. Member States shall take all appropriate measures to ensure that partly completed machinery can be placed on the market only if it satisfies the relevant provisions of this Directive.

3. Member States shall institute or appoint the competent authorities to monitor the conformity of machinery and partly completed machinery with the provisions set out in paragraphs 1 and 2.

4. Member States shall define the tasks, organisation and powers of the competent authorities referred to in paragraph 3 and shall notify the Commission and other Member States thereof and also of any subsequent amendment.

Article 5

Placing on the market and putting into service

1. Before placing machinery on the market and/or putting it into service, the manufacturer or his authorised representative shall:

(a) ensure that it satisfies the relevant essential health and safety requirements set out in Annex I;

(b) ensure that the technical file referred to in Annex VII, part A is available;

(c) provide, in particular, the necessary information, such as instructions;

(d) carry out the appropriate procedures for assessing conformity in accordance with Article 12;

(e) draw up the EC declaration of conformity in accordance with Annex II, part 1, Section A and ensure that it accompanies the machinery;

(f) affix the CE marking in accordance with Article 16.

2. Before placing partly completed machinery on the market, the manufacturer or his authorised representative shall ensure that the procedure referred to in Article 13 has been completed.

3. For the purposes of the procedures referred to in Article 12, the manufacturer or his authorised representative shall have, or shall have access to, the necessary means of ensuring that the machinery satisfies the essential health and safety requirements set out in Annex I.

4. Where machinery is also the subject of other Directives relating to other aspects and providing for the affixing of the CE marking, the marking shall indicate that the machinery also conforms to the provisions of those other Directives.

However, where one or more of those Directives allow the manufacturer or his authorised representative to choose, during a transitional period, the system to be applied, the CE marking shall indicate conformity only to the provisions of those Directives applied by the manufacturer or his authorised representative. Particulars of the Directives applied, as published in the *Official Journal of the European Union,* shall be given on the EC declaration of conformity.

Article 6

Freedom of movement

1. Member States shall not prohibit, restrict or impede the placing on the market and/or putting into service in their territory of machinery which complies with this Directive.

2. Member States shall not prohibit, restrict or impede the placing on the market of partly completed machinery where the manufacturer or his authorised representative makes a declaration of incorporation, referred to in Annex II, part 1, Section B, stating that it is to be incorporated into machinery or assembled with other partly completed machinery to form machinery.

3. At trade fairs, exhibitions, demonstrations, and such like, Member States shall not prevent the showing of machinery or partly completed machinery which does not conform to this Directive, provided that a visible sign clearly indicates that it does not conform and that it will not be made available until it has been brought into conformity. Furthermore, during demonstrations of such non-conforming machinery or partly completed machinery, adequate safety measures shall be taken to ensure the protection of persons.

Article 7

Presumption of conformity and harmonised standards

1. Member States shall regard machinery bearing the CE marking and accompanied by the EC declaration of conformity, the content of which is set out in Annex II, part 1, Section A, as complying with the provisions of this Directive.

2. Machinery manufactured in conformity with a harmonised standard, the references to which have been published in the *Official Journal of the European Union,* shall be presumed to comply with the essential health and safety requirements covered by such a harmonised standard.

3. The Commission shall publish in the *Official Journal of the European Union* the references of the harmonised standards.

4. Member States shall take the appropriate measures to enable the social partners to have an influence at national level on the process of preparing and monitoring the harmonised standards.

Article 8

Specific measures

1. The Commission, acting in accordance with the procedure referred to in Article 22(3), may take any appropriate measure to implement the provisions relating to the following points:

(a) updating of the indicative list of safety components in Annex V referred to in point (c) in Article 2;

(b) restriction of the placing on the market of machinery referred to in Article 9.

2. The Commission, acting in accordance with the procedure referred to in Article 22(2), may take any appropriate measure connected with the implementation and practical application of this Directive, including measures necessary to ensure cooperation of Member States with each other and with the Commission, as provided for in Article 19(1).

Article 9

Specific measures to deal with potentially hazardous machinery

1. When, in accordance with the procedure referred to in Article 10, the Commission considers that a harmonised standard does not entirely satisfy the essential health and safety requirements which it covers and which are set out in Annex I, the Commission may, in accordance with paragraph 3 of this Article, take measures requiring Member States to prohibit or restrict the placing on the market of machinery with technical characteristics presenting risks due to the shortcomings in the standard or to make such machinery subject to special conditions.

When, in accordance with the procedure referred to in Article 11, the Commission considers that a measure taken by a Member State is justified, the Commission may, in accordance with paragraph 3 of this Article, take measures requiring Member States to prohibit or restrict the placing on the market of machinery presenting the same risk by virtue of its technical characteristics or to make such machinery subject to special conditions.

2. Any Member State may request the Commission to examine the need for the adoption of the measures referred to in paragraph 1.

3. In the cases referred to in paragraph 1, the Commission shall consult the Member States and other interested parties indicating the measures it intends to take, in order to ensure, at Community level, a high level of protection of the health and safety of persons.

Taking due account of the results of this consultation, it shall adopt the necessary measures in accordance with the procedure referred to in Article 22(3).

Article 10

Procedure for disputing a harmonised standard

Where a Member State or the Commission considers that a harmonised standard does not entirely satisfy the essential health and safety requirements which it covers and which are set out in Annex I, the Commission or the Member State shall bring the matter before the committee set up by Directive 98/34/EC, setting out the reasons therefor. The committee shall deliver an opinion without delay. In the light of the committee's opinion, the Commission shall decide to publish, not to publish, to publish with restriction, to maintain, to maintain with restriction or to withdraw the references to the harmonised standard concerned in the *Official Journal of the European Union.*

Article 11

Safeguard clause

1. Where a Member State ascertains that machinery covered by this Directive, bearing the CE marking, accompanied by the EC declaration of conformity and used in accordance with its intended purpose or under conditions which can reasonably be foreseen, is liable to compromise the health and safety of persons and, where appropriate, domestic animals or property, it shall take

all appropriate measures to withdraw such machinery from the market, to prohibit the placing on the market and/or putting into service of such machinery or to restrict free movement thereof.

2. The Member State shall immediately inform the Commission and the other Member States of any such measure, indicating the reasons for its decision and, in particular, whether the non-conformity is due to:

(a) failure to satisfy the essential requirements referred to in Article 5(1)(a);

(b) incorrect application of the harmonised standards referred to in Article 7(2);

(c) shortcomings in the harmonised standards themselves referred to in Article 7(2).

3. The Commission shall enter into consultation with the parties concerned without delay.

The Commission shall consider, after this consultation, whether or not the measures taken by the Member State are justified, and it shall communicate its decision to the Member State which took the initiative, the other Member States, and the manufacturer or his authorised representative.

4. Where the measures referred to in paragraph 1 are based on a shortcoming in the harmonised standards and if the Member State which instigated the measures maintains its position, the Commission or the Member State shall initiate the procedure referred to in Article 10.

5. Where machinery does not conform and bears the CE marking, the competent Member State shall take appropriate action against whomsoever has affixed the marking and shall so inform the Commission. The Commission shall inform the other Member States.

6. The Commission shall ensure that Member States are kept informed of the progress and outcome of the procedure.

Article 12

Procedures for assessing the conformity of machinery

1. The manufacturer or his authorised representative shall, in order to certify the conformity of machinery with the provisions of this Directive, apply one of the procedures for assessment of conformity described in paragraphs 2, 3 and 4.

2. Where the machinery is not referred to in Annex IV, the manufacturer or his authorised representative shall apply the procedure for assessment of conformity with internal checks on the manufacture of machinery provided for in Annex VIII.

3. Where the machinery is referred to in Annex IV and manufactured in accordance with the harmonised standards referred to in Article 7(2), and provided that those standards cover all of the relevant essential health and safety requirements, the manufacturer or his authorised representative shall apply one of the following procedures:

(a) the procedure for assessment of conformity with internal checks on the manufacture of machinery, provided for in Annex VIII;

(b) the EC type-examination procedure provided for in Annex IX, plus the internal checks on the manufacture of machinery provided for in Annex VIII, point 3;

(c) the full quality assurance procedure provided for in Annex X.

4. Where the machinery is referred to in Annex IV and has not been manufactured in accordance with the harmonised standards referred to in Article 7(2), or only partly in accordance with such standards, or if the harmonised standards do not cover all the relevant essential health and safety

requirements or if no harmonised standards exist for the machinery in question, the manufacturer or his authorised representative shall apply one of the following procedures:

(a)the EC type-examination procedure provided for in Annex IX, plus the internal checks on the manufacture of machinery provided for in Annex VIII, point 3;

(b) the full quality assurance procedure provided for in Annex X.

Article 13

Procedure for partly completed machinery

1. The manufacturer of partly completed machinery or his authorised representative shall, before placing it on the market, ensure that:

(a) the relevant technical documentation described in Annex VII, part B is prepared;

(b) assembly instructions described in Annex VI are prepared;

(c) a declaration of incorporation described in Annex II, part 1, Section B has been drawn up.

2. The assembly instructions and the declaration of incorporation shall accompany the partly completed machinery until it is incorporated into the final machinery and shall then form part of the technical file for that machinery.

Article 14

Notified bodies

1. Member States shall notify the Commission and the other Member States of the bodies which they have appointed to carry out the assessment of conformity for placing on the market referred to in Article 12(3) and (4), together with the specific conformity assessment procedures and categories of machinery for which these bodies have been appointed and the identification numbers assigned to them beforehand by the Commission. Member States shall notify the Commission and other Member States of any subsequent amendment.

2. The Member States shall ensure that the notified bodies are monitored regularly to check that they comply at all times with the criteria set out in Annex XI. The notified body shall provide all relevant information on request, including budgetary documents, to enable the Member States to ensure that the requirements of Annex XI are met.

3. Member States shall apply the criteria set out in Annex XI in assessing the bodies to be notified and the bodies already notified.

4. The Commission shall publish in the *Official Journal of the European Union,* for information, a list of the notified bodies and their identification numbers and the tasks for which they have been notified. The Commission shall ensure that this list is kept up to date.

5. Bodies meeting the assessment criteria laid down in the relevant harmonised standards, the references of which shall be published in the *Official Journal of the European Union,* shall be presumed to fulfil the relevant criteria.

6. If a notified body finds that relevant requirements of this Directive have not been met or are no longer met by the manufacturer or that an EC type-examination certificate or the approval of a quality assurance system should not have been issued, it shall, taking account of the principle of proportionality, suspend or withdraw the certificate or the approval issued or place restrictions on it, giving detailed reasons, unless compliance with such requirements is ensured by the

implementation of appropriate corrective measures by the manufacturer. In the event of suspension or withdrawal of the certificate or the approval or of any restriction placed on it, or in cases where intervention by the competent authority may prove necessary, the notified body shall inform the competent authority pursuant to Article 4. The Member State shall inform the other Member States and the Commission without delay. An appeal procedure shall be available.

7. The Commission shall provide for the organisation of an exchange of experience between the authorities responsible for appointment, notification and monitoring of notified bodies in the Member States, and the notified bodies, in order to coordinate the uniform application of this Directive.

8. A Member State which has notified a body shall immediately withdraw its notification if it finds:

(a) that the body no longer meets the criteria set out in Annex XI; or

(b) that the body seriously fails to fulfil its responsibilities.

The Member State shall immediately inform the Commission and the other Member States accordingly.

Article 15

Installation and use of machinery

This Directive shall not affect Member States' entitlement to lay down, in due observance of Community law, such requirements as they may deem necessary to ensure that persons, and in particular workers, are protected when using machinery, provided that this does not mean that such machinery is modified in a way not specified in this Directive.

Article 16

CE marking

1. The CE conformity marking shall consist of the initials ‘CE’ as shown in Annex III.

2. The CE marking shall be affixed to the machinery visibly, legibly and indelibly in accordance with Annex III.

3. The affixing on machinery of markings, signs and inscriptions which are likely to mislead third parties as to the meaning or form of the CE marking, or both, shall be prohibited. Any other marking may be affixed to the machinery provided that the visibility, legibility and meaning of the CE marking is not thereby impaired.

Article 17

Non-conformity of marking

1. Member States shall consider the following marking not to conform:

(a) the affixing of the CE marking pursuant to this Directive on products not covered by this Directive;

(b) the absence of the CE marking and/or the absence of the EC declaration of conformity for machinery;

(c) the affixing on machinery of a marking, other than the CE marking, which is prohibited under Article 16(3).

2. Where a Member State ascertains that marking does not conform to the relevant provisions of this Directive, the manufacturer or his authorised representative shall be obliged to make the

product conform and to put an end to the infringement under conditions fixed by that Member State.

3. Where non-conformity persists, the Member State shall take all appropriate measures to restrict or prohibit the placing on the market of the product in question or to ensure that it is withdrawn from the market in accordance with the procedure laid down in Article 11.

Article 18

Confidentiality

1. Without prejudice to existing national provisions and practices in the area of confidentiality, Members States shall ensure that all parties and persons concerned by the application of this Directive are required to treat as confidential information obtained in the execution of their tasks. More particularly business, professional and trade secrets shall be treated as confidential, unless the divulging of such information is necessary in order to protect the health and safety of persons.

2. The provisions of paragraph 1 shall not affect the obligations of the Member States and the notified bodies with regard to mutual exchange of information and the issuing of warnings.

3. Any decisions taken by the Member States and by the Commission in accordance with Articles 9 and 11 shall be published.

Article 19

Cooperation between Member States

1. Member States shall take the appropriate measures to ensure that the competent authorities referred to in Article 4(3) cooperate with each other and with the Commission and transmit to each other the information necessary to enable this Directive to be applied uniformly.

2. The Commission shall provide for the organisation of an exchange of experience between the competent authorities responsible for market surveillance in order to coordinate the uniform application of this Directive.

Article 20

Legal remedies

Any measure taken pursuant to this Directive which restricts the placing on the market and/or putting into service of any machinery covered by this Directive shall state the exact grounds on which it is based. Such a measure shall be notified as soon as possible to the party concerned, who shall at the same time be informed of the legal remedies available to him under the laws in force in the Member State concerned and of the time limits to which such remedies are subject.

Article 21

Dissemination of information

The Commission shall take the necessary measures for appropriate information concerning the implementation of this Directive to be made available.

Article 22

Committee

1. The Commission shall be assisted by a committee, hereinafter referred to as the ‘Committee’.

2. Where reference is made to this paragraph, Articles 3 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

3. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.

4. The Committee shall adopt its rules of procedure.

Article 23

Penalties

Member States shall lay down the rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive and shall take all measures necessary to ensure that they are implemented. The penalties provided for must be effective, proportionate and dissuasive. Member States shall notify those provisions to the Commission by 29 June 2008 and shall notify it without delay of any subsequent amendment affecting them.

Article 24

Amendment of Directive 95/16/EC

Directive 95/16/EC is hereby amended as follows:

1.in Article 1, paragraphs 2 and 3 shall be replaced by the following:

2. 'For the purposes of this Directive, "lift" shall mean a lifting appliance serving specific levels, having a carrier moving along guides which are rigid and inclined at an angle of more than 15 degrees to the horizontal, intended for the transport of:

— persons,

— persons and goods,

—goods alone if the carrier is accessible, that is to say a person may enter it without difficulty, and fitted with controls situated inside the carrier or within reach of a person inside the carrier.

Lifting appliances moving along a fixed course even where they do not move along guides which are rigid shall be considered as lifts falling within the scope of this Directive.

A "carrier" means a part of the lift by which persons and/or goods are supported in order to be lifted or lowered.

3. This Directive shall not apply to:

— lifting appliances whose speed is not greater than 0,15 m/s,

— construction site hoists,

— cableways, including funicular railways,

— lifts specially designed and constructed for military or police purposes,

— lifting appliances from which work can be carried out,

— mine winding gear,

— lifting appliances intended for lifting performers during artistic performances,

— lifting appliances fitted in means of transport,

—lifting appliances connected to machinery and intended exclusively for access to workstations including maintenance and inspection points on the machinery,

— rack and pinion trains,

— escalators and mechanical walkways.';

2.in Annex I, point 1.2 shall be replaced by the following:

1.2. 'Carrier

The carrier of each lift must be a car. This car must be designed and constructed to offer the space and strength corresponding to the maximum number of persons and the rated load of the lift set by the installer.

Where the lift is intended for the transport of persons, and where its dimensions permit, the car must be designed and constructed in such a way that its structural features do not obstruct or impede access and use by disabled persons and so as to allow any appropriate adjustments intended to facilitate its use by them.'

Article 25

Repeal

Directive 98/37/EC is hereby repealed.

References made to the repealed Directive shall be construed as being made to this Directive and should be read in accordance with the correlation table in Annex XII.

Article 26

Transposition

1. Member States shall adopt and publish the provisions necessary to comply with this Directive by 29 June 2008 at the latest. They shall forthwith inform the Commission thereof.

They shall apply those provisions with effect from 29 December 2009.

When Member States adopt those provisions, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. Member States shall determine how such reference is to be made.

2. Member States shall communicate to the Commission the text of the provisions of national law which they adopt in the field covered by this Directive, together with a table showing how the provisions of this Directive correspond to the national provisions adopted.

Article 27

Derogation

Until 29 June 2011 Member States may allow the placing on the market and the putting into service of portable cartridge-operated fixing and other impact machinery which are in conformity with the national provisions in force upon adoption of this Directive.

Article 28

Entry into force

This Directive shall enter into force on the 20th day following its publication in the *Official Journal of the European Union.*

Article 29

Addressees

This Directive is addressed to the Member States.

Done at Strasbourg, 17 May 2006.

For the European Parliament

The President

J. BORRELL FONTELLES

For the Council

The President

H. WINKLER

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(1) OJ C 154 E, 29.5.2001, p. 164.

(2) OJ C 311, 7.11.2001, p. 1.

(3) Opinion of the European Parliament of 4 July 2002 (OJ C 271 E, 12.11.2003, p. 491), Council Common Position of 18 July 2005 (OJ C 251 E, 11.10.2005, p. 1) and Position of the European Parliament of 15 December 2005 (not yet published in the Official Journal). Council Decision of 25 April 2006.

(4) OJ L 207, 23.7.1998, p. 1. Directive as amended by Directive 98/79/EC (OJ L 331, 7.12.1998, p. 1).

(5) Council Directive 89/392/EEC of 14 June 1989 on the approximation of the laws of the Member States relating to machinery (OJ L 183, 29.6.1989, p. 9).

(6) OJ L 256, 13.9.1991, p. 51.

(7) OJ L 393, 30.12.1989, p. 13. Directive as last amended by Directive 2001/45/EC of the European Parliament and of the Council (OJ L 195, 19.7.2001, p. 46).

(8) OJ L 171, 9.7.2003, p. 1. Directive as last amended by Commission Directive 2005/67/EC (OJ L 273, 19.10.2005, p. 17).

(9) OJ L 220, 30.8.1993, p. 23.

(10) OJ L 213, 7.9.1995, p. 1. Directive as amended by Regulation (EC) No 1882/2003 (OJ L 284, 31.10.2003, p. 1).

(11) OJ C 321, 31.12.2003, p. 1.

(12) OJ L 184, 17.7.1999, p. 23.

(13) OJ L 42, 23.2.1970, p. 1. Directive as last amended by Commission Directive 2006/28/EC (OJ L 65, 7.3.2006, p. 27).

(14) OJ L 124, 9.5.2002, p. 1. Directive as last amended by Commission Directive 2005/30/EC (OJ L 106, 27.4.2005, p. 17).

(15) OJ L 77, 26.3.1973, p. 29. Directive as amended by Directive 93/68/EEC (OJ L 220, 30.8.1993, p. 1).

(16) OJ L 204, 21.7.1998, p. 37. Directive as last amended by the 2003 Act of Accession.

ANNEX I

Essential health and safety requirements relating to the the design and construction of machinery

GENERAL PRINCIPLES

1. The manufacturer of machinery or his authorised representative must ensure that a risk assessment is carried out in order to determine the health and safety requirements which apply to the machinery. The machinery must then be designed and constructed taking into account the results of the risk assessment.

   By the iterative process of risk assessment and risk reduction referred to above, the manufacturer or his authorised representative shall:

   —determine the limits of the machinery, which include the intended use and any reasonably foreseeable misuse thereof,

   —identify the hazards that can be generated by the machinery and the associated hazardous situations,

   —estimate the risks, taking into account the severity of the possible injury or damage to health and the probability of its occurrence,

   —evaluate the risks, with a view to determining whether risk reduction is required, in accordance with the objective of this Directive,

   —eliminate the hazards or reduce the risks associated with these hazards by application of protective measures, in the order of priority established in section 1.1.2(b).

2. The obligations laid down by the essential health and safety requirements only apply when the corresponding hazard exists for the machinery in question when it is used under the conditions foreseen by the manufacturer or his authorised representative or in foreseeable abnormal situations. In any event, the principles of safety integration referred to in section 1.1.2 and the obligations concerning marking of machinery and instructions referred to in sections 1.7.3 and 1.7.4 apply.

3. The essential health and safety requirements laid down in this Annex are mandatory; However, taking into account the state of the art, it may not be possible to meet the objectives set by them. In that event, the machinery must, as far as possible, be designed and constructed with the purpose of approaching these objectives.

4. This Annex is organised in several parts. The first one has a general scope and is applicable to all kinds of machinery. The other parts refer to certain kinds of more specific hazards. Nevertheless, it is essential to examine the whole of this Annex in order to be sure of meeting all the relevant essential requirements. When machinery is being designed, the requirements of the general part and the requirements of one or more of the other parts shall be taken into account, depending on the results of the risk assessment carried out in accordance with point 1 of these General Principles.

1. ESSENTIAL HEALTH AND SAFETY REQUIREMENTS

1.1. GENERAL REMARKS

1.1.1. Definitions

For the purpose of this Annex:

(a) ‘hazard’ means a potential source of injury or damage to health;

(b) ‘danger zone’ means any zone within and/or around machinery in which a person is subject to a risk to his health or safety;

(c) ‘exposed person’ means any person wholly or partially in a danger zone;

(d) ‘operator’ means the person or persons installing, operating, adjusting, maintaining, cleaning, repairing or moving machinery;

(e) ‘risk’ means a combination of the probability and the degree of an injury or damage to health that can arise in a hazardous situation;

(f) ‘guard’ means a part of the machinery used specifically to provide protection by means of a physical barrier;

(g)‘protective device’ means a device (other than a guard) which reduces the risk, either alone or in conjunction with a guard;

(h)‘intended use’ means the use of machinery in accordance with the information provided in the instructions for use;

(i)‘reasonably foreseeable misuse’ means the use of machinery in a way not intended in the instructions for use, but which may result from readily predictable human behaviour.

1.1.2. Principles of safety integration

(a)Machinery must be designed and constructed so that it is fitted for its function, and can be operated, adjusted and maintained without putting persons at risk when these operations are carried out under the conditions foreseen but also taking into account any reasonably foreseeable misuse thereof.

The aim of measures taken must be to eliminate any risk throughout the foreseeable lifetime of the machinery including the phases of transport, assembly, dismantling, disabling and scrapping.

(b)In selecting the most appropriate methods, the manufacturer or his authorised representative must apply the following principles, in the order given:

—eliminate or reduce risks as far as possible (inherently safe machinery design and construction),

— take the necessary protective measures in relation to risks that cannot be eliminated,

—inform users of the residual risks due to any shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment.

(c)When designing and constructing machinery and when drafting the instructions, the manufacturer or his authorised representative must envisage not only the intended use of the machinery but also any reasonably foreseeable misuse thereof.

The machinery must be designed and constructed in such a way as to prevent abnormal use if such use would engender a risk. Where appropriate, the instructions must draw the user's attention to ways — which experience has shown might occur — in which the machinery should not be used.

(d)Machinery must be designed and constructed to take account of the constraints to which the operator is subject as a result of the necessary or foreseeable use of personal protective equipment.

(e)Machinery must be supplied with all the special equipment and accessories essential to enable it to be adjusted, maintained and used safely.

1.1.3. Materials and products

The materials used to construct machinery or products used or created during its use must not endanger persons' safety or health. In particular, where fluids are used, machinery must be designed and constructed to prevent risks due to filling, use, recovery or draining.

1.1.4. Lighting

Machinery must be supplied with integral lighting suitable for the operations concerned where the absence thereof is likely to cause a risk despite ambient lighting of normal intensity.

Machinery must be designed and constructed so that there is no area of shadow likely to cause nuisance, that there is no irritating dazzle and that there are no dangerous stroboscopic effects on moving parts due to the lighting.

Internal parts requiring frequent inspection and adjustment, and maintenance areas must be provided with appropriate lighting.

1.1.5. Design of machinery to facilitate its handling

Machinery, or each component part thereof, must:

— be capable of being handled and transported safely,

— be packaged or designed so that it can be stored safely and without damage.

During the transportation of the machinery and/or its component parts, there must be no possibility of sudden movements or of hazards due to instability as long as the machinery and/or its component parts are handled in accordance with the instructions.

Where the weight, size or shape of machinery or its various component parts prevents them from being moved by hand, the machinery or each component part must:

— either be fitted with attachments for lifting gear, or

— be designed so that it can be fitted with such attachments, or

— be shaped in such a way that standard lifting gear can easily be attached.

Where machinery or one of its component parts is to be moved by hand, it must:

— either be easily moveable, or

— be equipped for picking up and moving safely.

Special arrangements must be made for the handling of tools and/or machinery parts which, even if lightweight, could be hazardous.

1.1.6. Ergonomics

Under the intended conditions of use, the discomfort, fatigue and physical and psychological stress faced by the operator must be reduced to the minimum possible, taking into account ergonomic principles such as:

— allowing for the variability of the operator's physical dimensions, strength and stamina,

— providing enough space for movements of the parts of the operator's body,

— avoiding a machine-determined work rate,

— avoiding monitoring that requires lengthy concentration,

— adapting the man/machinery interface to the foreseeable characteristics of the operators.

1.1.7. Operating positions

The operating position must be designed and constructed in such a way as to avoid any risk due to exhaust gases and/or lack of oxygen.

If the machinery is intended to be used in a hazardous environment presenting risks to the health and safety of the operator or if the machinery itself gives rise to a hazardous environment, adequate means must be provided to ensure that the operator has good working conditions and is protected against any foreseeable hazards.

Where appropriate, the operating position must be fitted with an adequate cabin designed, constructed and/or equipped to fulfil the above requirements. The exit must allow rapid evacuation. Moreover, when applicable, an emergency exit must be provided in a direction which is different from the usual exit.

1.1.8. Seating

Where appropriate and where the working conditions so permit, work stations constituting an integral part of the machinery must be designed for the installation of seats.

If the operator is intended to sit during operation and the operating position is an integral part of the machinery, the seat must be provided with the machinery.

The operator's seat must enable him to maintain a stable position. Furthermore, the seat and its distance from the control devices must be capable of being adapted to the operator.

If the machinery is subject to vibrations, the seat must be designed and constructed in such a way as to reduce the vibrations transmitted to the operator to the lowest level that is reasonably possible. The seat mountings must withstand all stresses to which they can be subjected. Where there is no floor beneath the feet of the operator, footrests covered with a slip-resistant material must be provided.

1.2. CONTROL SYSTEMS

1.2.1. Safety and reliability of control systems

Control systems must be designed and constructed in such a way as to prevent hazardous situations from arising. Above all, they must be designed and constructed in such a way that:

— they can withstand the intended operating stresses and external influences,

— a fault in the hardware or the software of the control system does not lead to hazardous situations,

— errors in the control system logic do not lead to hazardous situations,

— reasonably foreseeable human error during operation does not lead to hazardous situations.

Particular attention must be given to the following points:

— the machinery must not start unexpectedly,

— the parameters of the machinery must not change in an uncontrolled way, where such change may lead to hazardous situations,

— the machinery must not be prevented from stopping if the stop command has already been given,

— no moving part of the machinery or piece held by the machinery must fall or be ejected,

— automatic or manual stopping of the moving parts, whatever they may be, must be unimpeded,

— the protective devices must remain fully effective or give a stop command,

— the safety-related parts of the control system must apply in a coherent way to the whole of an assembly of machinery and/or partly completed machinery.

For cable-less control, an automatic stop must be activated when correct control signals are not received, including loss of communication.

1.2.2. Control devices

Control devices must be:

— clearly visible and identifiable, using pictograms where appropriate,

—positioned in such a way as to be safely operated without hesitation or loss of time and without ambiguity,

— designed in such a way that the movement of the control device is consistent with its effect,

—located outside the danger zones, except where necessary for certain control devices such as an emergency stop or a teach pendant,

— positioned in such a way that their operation cannot cause additional risk,

—designed or protected in such a way that the desired effect, where a hazard is involved, can only be achieved by a deliberate action,

—made in such a way as to withstand foreseeable forces; particular attention must be paid to emergency stop devices liable to be subjected to considerable forces.

Where a control device is designed and constructed to perform several different actions, namely where there is no one-to-one correspondence, the action to be performed must be clearly displayed and subject to confirmation, where necessary.

Control devices must be so arranged that their layout, travel and resistance to operation are compatible with the action to be performed, taking account of ergonomic principles.

Machinery must be fitted with indicators as required for safe operation. The operator must be able to read them from the control position.

From each control position, the operator must be able to ensure that no-one is in the danger zones, or the control system must be designed and constructed in such a way that starting is prevented while someone is in the danger zone.

If neither of these possibilities is applicable, before the machinery starts, an acoustic and/or visual warning signal must be given. The exposed persons must have time to leave the danger zone or prevent the machinery starting up.

If necessary, means must be provided to ensure that the machinery can be controlled only from control positions located in one or more predetermined zones or locations.

Where there is more than one control position, the control system must be designed in such a way that the use of one of them precludes the use of the others, except for stop controls and emergency stops.

When machinery has two or more operating positions, each position must be provided with all the required control devices without the operators hindering or putting each other into a hazardous situation.

1.2.3. Starting

It must be possible to start machinery only by voluntary actuation of a control device provided for the purpose.

The same requirement applies:

— when restarting the machinery after a stoppage, whatever the cause,

— when effecting a significant change in the operating conditions.

However, the restarting of the machinery or a change in operating conditions may be effected by voluntary actuation of a device other than the control device provided for the purpose, on condition that this does not lead to a hazardous situation.

For machinery functioning in automatic mode, the starting of the machinery, restarting after a stoppage, or a change in operating conditions may be possible without intervention, provided this does not lead to a hazardous situation.

Where machinery has several starting control devices and the operators can therefore put each other in danger, additional devices must be fitted to rule out such risks. If safety requires that starting and/or stopping must be performed in a specific sequence, there must be devices which ensure that these operations are performed in the correct order.

1.2.4. Stopping

1.2.4.1. Normal stop

Machinery must be fitted with a control device whereby the machinery can be brought safely to a complete stop.

Each workstation must be fitted with a control device to stop some or all of the functions of the machinery, depending on the existing hazards, so that the machinery is rendered safe.

The machinery's stop control must have priority over the start controls.

Once the machinery or its hazardous functions have stopped, the energy supply to the actuators concerned must be cut off.

1.2.4.2. Operational stop

Where, for operational reasons, a stop control that does not cut off the energy supply to the actuators is required, the stop condition must be monitored and maintained.

1.2.4.3. Emergency stop

Machinery must be fitted with one or more emergency stop devices to enable actual or impending danger to be averted.

The following exceptions apply:

—machinery in which an emergency stop device would not lessen the risk, either because it would not reduce the stopping time or because it would not enable the special measures required to deal with the risk to be taken,

— portable hand-held and/or hand-guided machinery.

The device must:

— have clearly identifiable, clearly visible and quickly accessible control devices,

— stop the hazardous process as quickly as possible, without creating additional risks,

— where necessary, trigger or permit the triggering of certain safeguard movements.

Once active operation of the emergency stop device has ceased following a stop command, that command must be sustained by engagement of the emergency stop device until that engagement is specifically overridden; it must not be possible to engage the device without triggering a stop command; it must be possible to disengage the device only by an appropriate operation, and disengaging the device must not restart the machinery but only permit restarting.

The emergency stop function must be available and operational at all times, regardless of the operating mode.

Emergency stop devices must be a back-up to other safeguarding measures and not a substitute for them.

1.2.4.4. Assembly of machinery

In the case of machinery or parts of machinery designed to work together, the machinery must be designed and constructed in such a way that the stop controls, including the emergency stop devices, can stop not only the machinery itself but also all related equipment, if its continued operation may be dangerous.

1.2.5. Selection of control or operating modes

The control or operating mode selected must override all other control or operating modes, with the exception of the emergency stop.

If machinery has been designed and constructed to allow its use in several control or operating modes requiring different protective measures and/or work procedures, it must be fitted with a mode selector which can be locked in each position. Each position of the selector must be clearly identifiable and must correspond to a single operating or control mode.

The selector may be replaced by another selection method which restricts the use of certain functions of the machinery to certain categories of operator.

If, for certain operations, the machinery must be able to operate with a guard displaced or removed and/or a protective device disabled, the control or operating mode selector must simultaneously:

— disable all other control or operating modes,

— permit operation of hazardous functions only by control devices requiring sustained action,

— permit the operation of hazardous functions only in reduced risk conditions while preventing hazards from linked sequences,

— prevent any operation of hazardous functions by voluntary or involuntary action on the machine's sensors.

If these four conditions cannot be fulfilled simultaneously, the control or operating mode selector must activate other protective measures designed and constructed to ensure a safe intervention zone.

In addition, the operator must be able to control operation of the parts he is working on from the adjustment point.

1.2.6. Failure of the power supply

The interruption, the re-establishment after an interruption or the fluctuation in whatever manner of the power supply to the machinery must not lead to dangerous situations.

Particular attention must be given to the following points:

— the machinery must not start unexpectedly,

— the parameters of the machinery must not change in an uncontrolled way when such change can lead to hazardous situations,

— the machinery must not be prevented from stopping if the command has already been given,

— no moving part of the machinery or piece held by the machinery must fall or be ejected,

— automatic or manual stopping of the moving parts, whatever they may be, must be unimpeded,

— the protective devices must remain fully effective or give a stop command.

1.3. PROTECTION AGAINST MECHANICAL HAZARDS

1.3.1. Risk of loss of stability

Machinery and its components and fittings must be stable enough to avoid overturning, falling or uncontrolled movements during transportation, assembly, dismantling and any other action involving the machinery.

If the shape of the machinery itself or its intended installation does not offer sufficient stability, appropriate means of anchorage must be incorporated and indicated in the instructions.

1.3.2. Risk of break-up during operation

The various parts of machinery and their linkages must be able to withstand the stresses to which they are subject when used.

The durability of the materials used must be adequate for the nature of the working environment foreseen by the manufacturer or his authorised representative, in particular as regards the phenomena of fatigue, ageing, corrosion and abrasion.

The instructions must indicate the type and frequency of inspections and maintenance required for safety reasons. They must, where appropriate, indicate the parts subject to wear and the criteria for replacement.

Where a risk of rupture or disintegration remains despite the measures taken, the parts concerned must be mounted, positioned and/or guarded in such a way that any fragments will be contained, preventing hazardous situations.

Both rigid and flexible pipes carrying fluids, particularly those under high pressure, must be able to withstand the foreseen internal and external stresses and must be firmly attached and/or protected to ensure that no risk is posed by a rupture.

Where the material to be processed is fed to the tool automatically, the following conditions must be fulfilled to avoid risks to persons:

— when the workpiece comes into contact with the tool, the latter must have attained its normal working condition,

— when the tool starts and/or stops (intentionally or accidentally), the feed movement and the tool movement must be coordinated.

1.3.3. Risks due to falling or ejected objects

Precautions must be taken to prevent risks from falling or ejected objects.

1.3.4. Risks due to surfaces, edges or angles

Insofar as their purpose allows, accessible parts of the machinery must have no sharp edges, no sharp angles and no rough surfaces likely to cause injury.

1.3.5. Risks related to combined machinery

Where the machinery is intended to carry out several different operations with manual removal of the piece between each operation (combined machinery), it must be designed and constructed in

such a way as to enable each element to be used separately without the other elements constituting a risk for exposed persons.

For this purpose, it must be possible to start and stop separately any elements that are not protected.

1.3.6. Risks related to variations in operating conditions

Where the machinery performs operations under different conditions of use, it must be designed and constructed in such a way that selection and adjustment of these conditions can be carried out safely and reliably.

1.3.7. Risks related to moving parts

The moving parts of machinery must be designed and constructed in such a way as to prevent risks of contact which could lead to accidents or must, where risks persist, be fitted with guards or protective devices.

All necessary steps must be taken to prevent accidental blockage of moving parts involved in the work. In cases where, despite the precautions taken, a blockage is likely to occur, the necessary specific protective devices and tools must, when appropriate, be provided to enable the equipment to be safely unblocked.

The instructions and, where possible, a sign on the machinery shall identify these specific protective devices and how they are to be used.

1.3.8. Choice of protection against risks arising from moving parts

Guards or protective devices designed to protect against risks arising from moving parts must be selected on the basis of the type of risk. The following guidelines must be used to help to make the choice.

1.3.8.1. Moving transmission parts

Guards designed to protect persons against the hazards generated by moving transmission parts must be:

— either fixed guards as referred to in section 1.4.2.1, or

— interlocking movable guards as referred to in section 1.4.2.2.

Interlocking movable guards should be used where frequent access is envisaged.

1.3.8.2. Moving parts involved in the process

Guards or protective devices designed to protect persons against the hazards generated by moving parts involved in the process must be:

— either fixed guards as referred to in section 1.4.2.1, or

— interlocking movable guards as referred to in section 1.4.2.2, or

— protective devices as referred to in section 1.4.3, or

— a combination of the above.

However, when certain moving parts directly involved in the process cannot be made completely inaccessible during operation owing to operations requiring operator intervention, such parts must be fitted with:

—fixed guards or interlocking movable guards preventing access to those sections of the parts that are not used in the work, and

—adjustable guards as referred to in section 1.4.2.3 restricting access to those sections of the moving parts where access is necessary.

1.3.9. Risks of uncontrolled movements

When a part of the machinery has been stopped, any drift away from the stopping position, for whatever reason other than action on the control devices, must be prevented or must be such that it does not present a hazard.

1.4. REQUIRED CHARACTERISTICS OF GUARDS AND PROTECTIVE DEVICES

1.4.1. General requirements

Guards and protective devices must:

— be of robust construction,

— be securely held in place,

— not give rise to any additional hazard,

— not be easy to by-pass or render non-operational,

— be located at an adequate distance from the danger zone,

— cause minimum obstruction to the view of the production process, and

—enable essential work to be carried out on the installation and/or replacement of tools and for maintenance purposes by restricting access exclusively to the area where the work has to be done, if possible without the guard having to be removed or the protective device having to be disabled.

In addition, guards must, where possible, protect against the ejection or falling of materials or objects and against emissions generated by the machinery.

1.4.2. Special requirements for guards

1.4.2.1. Fixed guards

Fixed guards must be fixed by systems that can be opened or removed only with tools.

Their fixing systems must remain attached to the guards or to the machinery when the guards are removed.

Where possible, guards must be incapable of remaining in place without their fixings.

1.4.2.2. Interlocking movable guards

Interlocking movable guards must:

— as far as possible remain attached to the machinery when open,

—be designed and constructed in such a way that they can be adjusted only by means of an intentional action.

Interlocking movable guards must be associated with an interlocking device that:

— prevents the start of hazardous machinery functions until they are closed and

— gives a stop command whenever they are no longer closed.

Where it is possible for an operator to reach the danger zone before the risk due to the hazardous machinery functions has ceased, movable guards must be associated with a guard locking device in addition to an interlocking device that:

— prevents the start of hazardous machinery functions until the guard is closed and locked, and

— keeps the guard closed and locked until the risk of injury from the hazardous machinery functions has ceased.

Interlocking movable guards must be designed in such a way that the absence or failure of one of their components prevents starting or stops the hazardous machinery functions.

1.4.2.3. Adjustable guards restricting access

Adjustable guards restricting access to those areas of the moving parts strictly necessary for the work must be:

— adjustable manually or automatically, depending on the type of work involved, and

— readily adjustable without the use of tools.

1.4.3. Special requirements for protective devices

Protective devices must be designed and incorporated into the control system in such a way that:

— moving parts cannot start up while they are within the operator's reach,

— persons cannot reach moving parts while the parts are moving, and

— the absence or failure of one of their components prevents starting or stops the moving parts.

Protective devices must be adjustable only by means of an intentional action.

1.5. RISKS DUE TO OTHER HAZARDS

1.5.1. Electricity supply

Where machinery has an electricity supply, it must be designed, constructed and equipped in such a way that all hazards of an electrical nature are or can be prevented.

The safety objectives set out in Directive 73/23/EEC shall apply to machinery. However, the obligations concerning conformity assessment and the placing on the market and/or putting into service of machinery with regard to electrical hazards are governed solely by this Directive.

1.5.2. Static electricity

Machinery must be designed and constructed to prevent or limit the build-up of potentially dangerous electrostatic charges and/or be fitted with a discharging system.

1.5.3. Energy supply other than electricity

Where machinery is powered by source of energy other than electricity, it must be so designed, constructed and equipped as to avoid all potential risks associated with such sources of energy.

1.5.4. Errors of fitting

Errors likely to be made when fitting or refitting certain parts which could be a source of risk must be made impossible by the design and construction of such parts or, failing this, by information given on the parts themselves and/or their housings. The same information must be given on

moving parts and/or their housings where the direction of movement needs to be known in order to avoid a risk.

Where necessary, the instructions must give further information on these risks.

Where a faulty connection can be the source of risk, incorrect connections must be made impossible by design or, failing this, by information given on the elements to be connected and, where appropriate, on the means of connection.

1.5.5. Extreme temperatures

Steps must be taken to eliminate any risk of injury arising from contact with or proximity to machinery parts or materials at high or very low temperatures.

The necessary steps must also be taken to avoid or protect against the risk of hot or very cold material being ejected.

1.5.6. Fire

Machinery must be designed and constructed in such a way as to avoid any risk of fire or overheating posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery.

1.5.7. Explosion

Machinery must be designed and constructed in such a way as to avoid any risk of explosion posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery.

Machinery must comply, as far as the risk of explosion due to its use in a potentially explosive atmosphere is concerned, with the provisions of the specific Community Directives.

1.5.8. Noise

Machinery must be designed and constructed in such a way that risks resulting from the emission of airborne noise are reduced to the lowest level, taking account of technical progress and the availability of means of reducing noise, in particular at source.

The level of noise emission may be assessed with reference to comparative emission data for similar machinery.

1.5.9. Vibrations

Machinery must be designed and constructed in such a way that risks resulting from vibrations produced by the machinery are reduced to the lowest level, taking account of technical progress and the availability of means of reducing vibration, in particular at source.

The level of vibration emission may be assessed with reference to comparative emission data for similar machinery.

1.5.10. Radiation

Undesirable radiation emissions from the machinery must be eliminated or be reduced to levels that do not have adverse effects on persons.

Any functional ionising radiation emissions must be limited to the lowest level which is sufficient for the proper functioning of the machinery during setting, operation and cleaning. Where a risk exists, the necessary protective measures must be taken.

Any functional non-ionising radiation emissions during setting, operation and cleaning must be limited to levels that do not have adverse effects on persons.

1.5.11. External radiation

Machinery must be designed and constructed in such a way that external radiation does not interfere with its operation.

1.5.12. Laser radiation

Where laser equipment is used, the following should be taken into account:

—laser equipment on machinery must be designed and constructed in such a way as to prevent any accidental radiation,

—laser equipment on machinery must be protected in such a way that effective radiation, radiation produced by reflection or diffusion and secondary radiation do not damage health,

—optical equipment for the observation or adjustment of laser equipment on machinery must be such that no health risk is created by laser radiation.

1.5.13. Emissions of hazardous materials and substances

Machinery must be designed and constructed in such a way that risks of inhalation, ingestion, contact with the skin, eyes and mucous membranes and penetration through the skin of hazardous materials and substances which it produces can be avoided.

Where a hazard cannot be eliminated, the machinery must be so equipped that hazardous materials and substances can be contained, evacuated, precipitated by water spraying, filtered or treated by another equally effective method.

Where the process is not totally enclosed during normal operation of the machinery, the devices for containment and/or evacuation must be situated in such a way as to have the maximum effect.

1.5.14. Risk of being trapped in a machine

Machinery must be designed, constructed or fitted with a means of preventing a person from being enclosed within it or, if that is impossible, with a means of summoning help.

1.5.15. Risk of slipping, tripping or falling

Parts of the machinery where persons are liable to move about or stand must be designed and constructed in such a way as to prevent persons slipping, tripping or falling on or off these parts.

Where appropriate, these parts must be fitted with handholds that are fixed relative to the user and that enable them to maintain their stability.

1.5.16. Lightning

Machinery in need of protection against the effects of lightning while being used must be fitted with a system for conducting the resultant electrical charge to earth.

1.6. MAINTENANCE

1.6.1. Machinery maintenance

Adjustment and maintenance points must be located outside danger zones. It must be possible to carry out adjustment, maintenance, repair, cleaning and servicing operations while machinery is at a standstill.

If one or more of the above conditions cannot be satisfied for technical reasons, measures must be taken to ensure that these operations can be carried out safely (see section 1.2.5).

In the case of automated machinery and, where necessary, other machinery, a connecting device for mounting diagnostic fault-finding equipment must be provided.

Automated machinery components which have to be changed frequently must be capable of being removed and replaced easily and safely. Access to the components must enable these tasks to be carried out with the necessary technical means in accordance with a specified operating method.

1.6.2. Access to operating positions and servicing points

Machinery must be designed and constructed in such a way as to allow access in safety to all areas where intervention is necessary during operation, adjustment and maintenance of the machinery.

1.6.3. Isolation of energy sources

Machinery must be fitted with means to isolate it from all energy sources. Such isolators must be clearly identified. They must be capable of being locked if reconnection could endanger persons. Isolators must also be capable of being locked where an operator is unable, from any of the points to which he has access, to check that the energy is still cut off.

In the case of machinery capable of being plugged into an electricity supply, removal of the plug is sufficient, provided that the operator can check from any of the points to which he has access that the plug remains removed.

After the energy is cut off, it must be possible to dissipate normally any energy remaining or stored in the circuits of the machinery without risk to persons.

As an exception to the requirement laid down in the previous paragraphs, certain circuits may remain connected to their energy sources in order, for example, to hold parts, to protect information, to light interiors, etc. In this case, special steps must be taken to ensure operator safety.

1.6.4. Operator intervention

Machinery must be so designed, constructed and equipped that the need for operator intervention is limited. If operator intervention cannot be avoided, it must be possible to carry it out easily and safely.

1.6.5. Cleaning of internal parts

The machinery must be designed and constructed in such a way that it is possible to clean internal parts which have contained dangerous substances or preparations without entering them; any necessary unblocking must also be possible from the outside. If it is impossible to avoid entering the machinery, it must be designed and constructed in such a way as to allow cleaning to take place safely.

1.7. INFORMATION

1.7.1. Information and warnings on the machinery

Information and warnings on the machinery should preferably be provided in the form of readily understandable symbols or pictograms. Any written or verbal information and warnings must be expressed in an official Community language or languages, which may be determined in accordance with the Treaty by the Member State in which the machinery is placed on the market and/or put into service and may be accompanied, on request, by versions in any other official Community language or languages understood by the operators.

1.7.1.1. Information and information devices

The information needed to control machinery must be provided in a form that is unambiguous and easily understood. It must not be excessive to the extent of overloading the operator.

Visual display units or any other interactive means of communication between the operator and the machine must be easily understood and easy to use.

1.7.1.2. Warning devices

Where the health and safety of persons may be endangered by a fault in the operation of unsupervised machinery, the machinery must be equipped in such a way as to give an appropriate acoustic or light signal as a warning.

Where machinery is equipped with warning devices these must be unambiguous and easily perceived. The operator must have facilities to check the operation of such warning devices at all times.

The requirements of the specific Community Directives concerning colours and safety signals must be complied with.

1.7.2. Warning of residual risks

Where risks remain despite the inherent safe design measures, safeguarding and complementary protective measures adopted, the necessary warnings, including warning devices, must be provided.

1.7.3. Marking of machinery

All machinery must be marked visibly, legibly and indelibly with the following minimum particulars:

—the business name and full address of the manufacturer and, where applicable, his authorised representative,

— designation of the machinery,

— the CE Marking (see Annex III),

— designation of series or type,

— serial number, if any,

— the year of construction, that is the year in which the manufacturing process is completed.

It is prohibited to pre-date or post-date the machinery when affixing the CE marking.

Furthermore, machinery designed and constructed for use in a potentially explosive atmosphere must be marked accordingly.

Machinery must also bear full information relevant to its type and essential for safe use. Such information is subject to the requirements set out in section 1.7.1.

Where a machine part must be handled during use with lifting equipment, its mass must be indicated legibly, indelibly and unambiguously.

1.7.4. Instructions

All machinery must be accompanied by instructions in the official Community language or languages of the Member State in which it is placed on the market and/or put into service.

The instructions accompanying the machinery must be either 'Original instructions' or a 'Translation of the original instructions', in which case the translation must be accompanied by the original instructions.

By way of exception, the maintenance instructions intended for use by specialised personnel mandated by the manufacturer or his authorised representative may be supplied in only one Community language which the specialised personnel understand.

The instructions must be drafted in accordance with the principles set out below.

1.7.4.1. General principles for the drafting of instructions

(a) The instructions must be drafted in one or more official Community languages. The words 'Original instructions' must appear on the language version(s) verified by the manufacturer or his authorised representative.

(b) Where no 'Original instructions' exist in the official language(s) of the country where the machinery is to be used, a translation into that/those language(s) must be provided by the manufacturer or his authorised representative or by the person bringing the machinery into the language area in question. The translations must bear the words 'Translation of the original instructions'.

(c) The contents of the instructions must cover not only the intended use of the machinery but also take into account any reasonably foreseeable misuse thereof.

(d) In the case of machinery intended for use by non-professional operators, the wording and layout of the instructions for use must take into account the level of general education and acumen that can reasonably be expected from such operators.

1.7.4.2. Contents of the instructions

Each instruction manual must contain, where applicable, at least the following information:

(a) the business name and full address of the manufacturer and of his authorised representative;

(b) the designation of the machinery as marked on the machinery itself, except for the serial number (see section 1.7.3);

(c) the EC declaration of conformity, or a document setting out the contents of the EC declaration of conformity, showing the particulars of the machinery, not necessarily including the serial number and the signature;

(d) a general description of the machinery;

(e) the drawings, diagrams, descriptions and explanations necessary for the use, maintenance and repair of the machinery and for checking its correct functioning;

(f) a description of the workstation(s) likely to be occupied by operators;

(g) a description of the intended use of the machinery;

(h)warnings concerning ways in which the machinery must not be used that experience has shown might occur;

(i)assembly, installation and connection instructions, including drawings, diagrams and the means of attachment and the designation of the chassis or installation on which the machinery is to be mounted;

(j) instructions relating to installation and assembly for reducing noise or vibration;

(k)instructions for the putting into service and use of the machinery and, if necessary, instructions for the training of operators;

(l)information about the residual risks that remain despite the inherent safe design measures, safeguarding and complementary protective measures adopted;

(m)instructions on the protective measures to be taken by the user, including, where appropriate, the personal protective equipment to be provided;

(n) the essential characteristics of tools which may be fitted to the machinery;

(o)the conditions in which the machinery meets the requirement of stability during use, transportation, assembly, dismantling when out of service, testing or foreseeable breakdowns;

(p)instructions with a view to ensuring that transport, handling and storage operations can be made safely, giving the mass of the machinery and of its various parts where these are regularly to be transported separately;

(q)the operating method to be followed in the event of accident or breakdown; if a blockage is likely to occur, the operating method to be followed so as to enable the equipment to be safely unblocked;

(r)the description of the adjustment and maintenance operations that should be carried out by the user and the preventive maintenance measures that should be observed;

(s)instructions designed to enable adjustment and maintenance to be carried out safely, including the protective measures that should be taken during these operations;

(t)the specifications of the spare parts to be used, when these affect the health and safety of operators;

(u)the following information on airborne noise emissions:

—the A-weighted emission sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact must be indicated,

—the peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20 μPa),

—the A-weighted sound power level emitted by the machinery, where the A-weighted emission sound pressure level at workstations exceeds 80 dB(A).

These values must be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery which is representative of the machinery to be produced.

In the case of very large machinery, instead of the A-weighted sound power level, the A-weighted emission sound pressure levels at specified positions around the machinery may be indicated.

Where the harmonised standards are not applied, sound levels must be measured using the most appropriate method for the machinery. Whenever sound emission values are indicated the uncertainties surrounding these values must be specified. The operating conditions of the machinery during measurement and the measuring methods used must be described.

Where the workstation(s) are undefined or cannot be defined, A-weighted sound pressure levels must be measured at a distance of 1 metre from the surface of the machinery and at a height of 1,6 metres from the floor or access platform. The position and value of the maximum sound pressure must be indicated.

Where specific Community Directives lay down other requirements for the measurement of sound pressure levels or sound power levels, those Directives must be applied and the corresponding provisions of this section shall not apply;

(v) where machinery is likely to emit non-ionising radiation which may cause harm to persons, in particular persons with active or non-active implantable medical devices, information concerning the radiation emitted for the operator and exposed persons.

1.7.4.3. Sales literature

Sales literature describing the machinery must not contradict the instructions as regards health and safety aspects. Sales literature describing the performance characteristics of machinery must contain the same information on emissions as is contained in the instructions.

2. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR CERTAIN CATEGORIES OF MACHINERY

Foodstuffs machinery, machinery for cosmetics or pharmaceutical products, hand-held and/or hand-guided machinery, portable fixing and other impact machinery, machinery for working wood and material with similar physical characteristics must meet all the essential health and safety requirements described in this chapter (see General Principles, point 4).

2.1. FOODSTUFFS MACHINERY AND MACHINERY FOR COSMETICS OR PHARMACEUTICAL PRODUCTS

2.1.1. General

Machinery intended for use with foodstuffs or with cosmetics or pharmaceutical products must be designed and constructed in such a way as to avoid any risk of infection, sickness or contagion.

The following requirements must be observed:

(a) materials in contact with, or intended to come into contact with, foodstuffs or cosmetics or pharmaceutical products must satisfy the conditions set down in the relevant Directives. The machinery must be designed and constructed in such a way that these materials can be cleaned before each use. Where this is not possible disposable parts must be used;

(b) all surfaces in contact with foodstuffs or cosmetics or pharmaceutical products, other than surfaces of disposable parts, must:

— be smooth and have neither ridges nor crevices which could harbour organic materials. The same applies to their joinings,

— be designed and constructed in such a way as to reduce the projections, edges and recesses of assemblies to a minimum,

— be easily cleaned and disinfected, where necessary after removing easily dismantled parts; the inside surfaces must have curves with a radius sufficient to allow thorough cleaning;

(c) it must be possible for liquids, gases and aerosols deriving from foodstuffs, cosmetics or pharmaceutical products as well as from cleaning, disinfecting and rinsing fluids to be completely discharged from the machinery (if possible, in a ‘cleaning’ position);

(d)machinery must be designed and constructed in such a way as to prevent any substances or living creatures, in particular insects, from entering, or any organic matter from accumulating in, areas that cannot be cleaned;

(e)machinery must be designed and constructed in such a way that no ancillary substances hazardous to health, including the lubricants used, can come into contact with foodstuffs, cosmetics or pharmaceutical products. Where necessary, machinery must be designed and constructed in such a way that continuing compliance with this requirement can be checked.

2.1.2. Instructions

The instructions for foodstuffs machinery and machinery for use with cosmetics or pharmaceutical products must indicate recommended products and methods for cleaning, disinfecting and rinsing, not only for easily accessible areas but also for areas to which access is impossible or inadvisable.

2.2. PORTABLE HAND-HELD AND/OR HAND-GUIDED MACHINERY

2.2.1. General

Portable hand-held and/or hand-guided machinery must:

—depending on the type of machinery, have a supporting surface of sufficient size and have a sufficient number of handles and supports of an appropriate size, arranged in such a way as to ensure the stability of the machinery under the intended operating conditions,

—except where technically impossible, or where there is an independent control device, in the case of handles which cannot be released in complete safety, be fitted with manual start and stop control devices arranged in such a way that the operator can operate them without releasing the handles,

—present no risks of accidental starting and/or continued operation after the operator has released the handles. Equivalent steps must be taken if this requirement is not technically feasible,

—permit, where necessary, visual observation of the danger zone and of the action of the tool with the material being processed.

The handles of portable machinery must be designed and constructed in such a way as to make starting and stopping straightforward.

2.2.1.1. Instructions

The instructions must give the following information concerning vibrations transmitted by portable hand-held and hand-guided machinery:

—the vibration total value to which the hand-arm system is subjected, if it exceeds 2,5 m/s^2. Where this value does not exceed 2,5 m/s^2, this must be mentioned,

— the uncertainty of measurement.

These values must be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery which is representative of the machinery to be produced.

If harmonised standards are not applied, the vibration data must be measured using the most appropriate measurement code for the machinery.

The operating conditions during measurement and the methods used for measurement, or the reference of the harmonised standard applied, must be specified.

2.2.2. Portable fixing and other impact machinery

2.2.2.1. General

Portable fixing and other impact machinery must be designed and constructed in such a way that:

—energy is transmitted to the impacted element by the intermediary component that does not leave the device,

—an enabling device prevents impact unless the machinery is positioned correctly with adequate pressure on the base material,

—involuntary triggering is prevented; where necessary, an appropriate sequence of actions on the enabling device and the control device must be required to trigger an impact,

— accidental triggering is prevented during handling or in case of shock,

— loading and unloading operations can be carried out easily and safely.

Where necessary, it must be possible to fit the device with splinter guard(s) and the appropriate guard(s) must be provided by the manufacturer of the machinery.

2.2.2.2. Instructions

The instructions must give the necessary information regarding:

— the accessories and interchangeable equipment that can be used with the machinery,

— the suitable fixing or other impacted elements to be used with the machinery,

— where appropriate, the suitable cartridges to be used.

2.3. MACHINERY FOR WORKING WOOD AND MATERIAL WITH SIMILAR PHYSICAL CHARACTERISTICS

Machinery for working wood and materials with similar physical characteristics must comply with the following requirements:

(a)the machinery must be designed, constructed or equipped in such a way that the piece being machined can be placed and guided in safety; where the piece is hand-held on a work-bench, the latter must be sufficiently stable during the work and must not impede the movement of the piece;

(b)where the machinery is likely to be used in conditions involving the risk of ejection of workpieces or parts of them, it must be designed, constructed, or equipped in such a way as to prevent such ejection, or, if this is not possible, so that the ejection does not engender risks for the operator and/or exposed persons;

(c)the machinery must be equipped with an automatic brake that stops the tool in a sufficiently short time if there is a risk of contact with the tool whilst it runs down;

(d)where the tool is incorporated into a non-fully automated machine, the latter must be designed and constructed in such a way as to eliminate or reduce the risk of accidental injury.

3. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET HAZARDS DUE TO THE MOBILITY OF MACHINERY

Machinery presenting hazards due to its mobility must meet all the essential health and safety requirements described in this chapter (see General Principles, point 4).

3.1. GENERAL

3.1.1. Definitions

(a)‘Machinery presenting hazards due to its mobility’ means

—machinery the operation of which requires either mobility while working, or continuous or semi-continuous movement between a succession of fixed working locations, or

—machinery which is operated without being moved, but which may be equipped in such a way as to enable it to be moved more easily from one place to another.

(b)‘Driver’ means an operator responsible for the movement of a machine. The driver may be transported by the machinery or may be on foot, accompanying the machinery, or may guide the machinery by remote control.

3.2. WORK POSITIONS

3.2.1. Driving position

Visibility from the driving position must be such that the driver can, in complete safety for himself and the exposed persons, operate the machinery and its tools in their foreseeable conditions of use. Where necessary, appropriate devices must be provided to remedy hazards due to inadequate direct vision.

Machinery on which the driver is transported must be designed and constructed in such a way that, from the driving positions, there is no risk to the driver from inadvertent contact with the wheels and tracks.

The driving position of ride-on drivers must be designed and constructed in such a way that a driver's cab may be fitted, provided this does not increase the risk and there is room for it. The cab must incorporate a place for the instructions needed for the driver.

3.2.2. Seating

Where there is a risk that operators or other persons transported by the machinery may be crushed between parts of the machinery and the ground should the machinery roll or tip over, in particular for machinery equipped with a protective structure referred to in section 3.4.3 or 3.4.4, their seats must be designed or equipped with a restraint system so as to keep the persons in their seats, without restricting movements necessary for operations or movements relative to the structure caused by the suspension of the seats. Such restraint systems should not be fitted if they increase the risk.

3.2.3. Positions for other persons

If the conditions of use provide that persons other than the driver may occasionally or regularly be transported by the machinery or work on it, appropriate positions must be provided which enable them to be transported or to work on it without risk.

The second and third paragraphs of section 3.2.1 also apply to the places provided for persons other than the driver.

3.3. CONTROL SYSTEMS

If necessary, steps must be taken to prevent unauthorised use of controls.

In the case of remote controls, each control unit must clearly identify the machinery to be controlled from that unit.

The remote control system must be designed and constructed in such a way as to affect only:

— the machinery in question,

— the functions in question.

Remote controlled machinery must be designed and constructed in such a way that it will respond only to signals from the intended control units.

3.3.1. Control devices

The driver must be able to actuate all control devices required to operate the machinery from the driving position, except for functions which can be safely actuated only by using control devices located elsewhere. These functions include, in particular, those for which operators other than the driver are responsible or for which the driver has to leave the driving position in order to control them safely.

Where there are pedals, they must be so designed, constructed and fitted as to allow safe operation by the driver with the minimum risk of incorrect operation. They must have a slip-resistant surface and be easy to clean.

Where their operation can lead to hazards, notably dangerous movements, the control devices, except for those with preset positions, must return to the neutral position as soon as they are released by the operator.

In the case of wheeled machinery, the steering system must be designed and constructed in such a way as to reduce the force of sudden movements of the steering wheel or the steering lever caused by shocks to the guide wheels.

Any control that locks the differential must be so designed and arranged that it allows the differential to be unlocked when the machinery is moving.

The sixth paragraph of section 1.2.2, concerning acoustic and/or visual warning signals, applies only in the case of reversing.

3.3.2. Starting/moving

All travel movements of self-propelled machinery with a ride-on driver must be possible only if the driver is at the controls.

Where, for operating purposes, machinery is fitted with devices which exceed its normal clearance zone (e.g. stabilisers, jib, etc.), the driver must be provided with the means of checking easily, before moving the machinery, that such devices are in a particular position which allows safe movement.

This also applies to all other parts which, to allow safe movement, have to be in particular positions, locked if necessary.

Where it does not give rise to other risks, movement of the machinery must depend on safe positioning of the aforementioned parts.

It must not be possible for unintentional movement of the machinery to occur while the engine is being started.

3.3.3. Travelling function

Without prejudice to road traffic regulations, self-propelled machinery and its trailers must meet the requirements for slowing down, stopping, braking and immobilisation so as to ensure safety under all the operating, load, speed, ground and gradient conditions allowed for.

The driver must be able to slow down and stop self-propelled machinery by means of a main device. Where safety so requires, in the event of a failure of the main device, or in the absence of the energy supply needed to actuate the main device, an emergency device with a fully independent and easily accessible control device must be provided for slowing down and stopping.

Where safety so requires, a parking device must be provided to render stationary machinery immobile. This device may be combined with one of the devices referred to in the second paragraph, provided that it is purely mechanical.

Remote-controlled machinery must be equipped with devices for stopping operation automatically and immediately and for preventing potentially dangerous operation in the following situations:

— if the driver loses control,

— if it receives a stop signal,

— if a fault is detected in a safety-related part of the system,

— if no validation signal is detected within a specified time.

Section 1.2.4 does not apply to the travelling function.

3.3.4. Movement of pedestrian-controlled machinery

Movement of pedestrian-controlled self-propelled machinery must be possible only through sustained action on the relevant control device by the driver. In particular, it must not be possible for movement to occur while the engine is being started.

The control systems for pedestrian-controlled machinery must be designed in such a way as to minimise the risks arising from inadvertent movement of the machine towards the driver, in particular:

— crushing,

— injury from rotating tools.

The speed of travel of the machinery must be compatible with the pace of a driver on foot.

In the case of machinery on which a rotary tool may be fitted, it must not be possible to actuate the tool when the reverse control is engaged, except where the movement of the machinery results from movement of the tool. In the latter case, the reversing speed must be such that it does not endanger the driver.

3.3.5. Control circuit failure

A failure in the power supply to the power-assisted steering, where fitted, must not prevent machinery from being steered during the time required to stop it.

3.4. PROTECTION AGAINST MECHANICAL HAZARDS

3.4.1. Uncontrolled movements

Machinery must be designed, constructed and where appropriate placed on its mobile support in such a way as to ensure that, when moved, uncontrolled oscillations of its centre of gravity do not affect its stability or exert excessive strain on its structure.

3.4.2. Moving transmission parts

By way of exception to section 1.3.8.1, in the case of engines, moveable guards preventing access to the moving parts in the engine compartment need not have interlocking devices if they have to be opened either by the use of a tool or key or by a control located in the driving position, providing the latter is in a fully enclosed cab with a lock to prevent unauthorised access.

3.4.3. Roll-over and tip-over

Where, in the case of self-propelled machinery with a ride-on driver, operator(s) or other person(s), there is a risk of rolling or tipping over, the machinery must be fitted with an appropriate protective structure, unless this increases the risk.

This structure must be such that in the event of rolling or tipping over it affords the ride-on person(s) an adequate deflection-limiting volume.

In order to verify that the structure complies with the requirement laid down in the second paragraph, the manufacturer or his authorised representative must, for each type of structure concerned, perform appropriate tests or have such tests performed.

3.4.4. Falling objects

Where, in the case of self-propelled machinery with a ride-on driver, operator(s) or other person(s), there is a risk due to falling objects or material, the machinery must be designed and constructed in such a way as to take account of this risk and fitted, if its size allows, with an appropriate protective structure.

This structure must be such that, in the event of falling objects or material, it guarantees the ride-on person(s) an adequate deflection-limiting volume.

In order to verify that the structure complies with the requirement laid down in the second paragraph, the manufacturer or his authorised representative must, for each type of structure concerned, perform appropriate tests or have such tests performed.

3.4.5. Means of access

Handholds and steps must be designed, constructed and arranged in such a way that the operators use them instinctively and do not use the control devices to assist access.

3.4.6. Towing devices

All machinery used to tow or to be towed must be fitted with towing or coupling devices designed, constructed and arranged in such a way as to ensure easy and secure connection and disconnection and to prevent accidental disconnection during use.

Insofar as the tow bar load so requires, such machinery must be equipped with a support with a bearing surface suited to the load and the ground.

3.4.7. Transmission of power between self-propelled machinery (or tractor) and recipient machinery

Removable mechanical transmission devices linking self-propelled machinery (or a tractor) to the first fixed bearing of recipient machinery must be designed and constructed in such a way that any part that moves during operation is protected over its whole length.

On the side of the self-propelled machinery (or tractor), the power take-off to which the removable mechanical transmission device is attached must be protected either by a guard fixed and linked to the self-propelled machinery (or tractor) or by any other device offering equivalent protection.

It must be possible to open this guard for access to the removable transmission device. Once it is in place, there must be enough room to prevent the drive shaft damaging the guard when the machinery (or the tractor) is moving.

On the recipient machinery side, the input shaft must be enclosed in a protective casing fixed to the machinery.

Torque limiters or freewheels may be fitted to universal joint transmissions only on the side adjoining the driven machinery. The removable mechanical transmission device must be marked accordingly.

All recipient machinery, the operation of which requires a removable mechanical transmission device to connect it to self-propelled machinery (or a tractor), must have a system for attaching the removable mechanical transmission device so that, when the machinery is uncoupled, the removable mechanical transmission device and its guard are not damaged by contact with the ground or part of the machinery.

The outside parts of the guard must be so designed, constructed and arranged that they cannot turn with the removable mechanical transmission device. The guard must cover the transmission to the ends of the inner jaws in the case of simple universal joints and at least to the centre of the outer joint or joints in the case of wide-angle universal joints.

If means of access to working positions are provided near to the removable mechanical transmission device, they must be designed and constructed in such a way that the shaft guards cannot be used as steps, unless designed and constructed for that purpose.

3.5. PROTECTION AGAINST OTHER HAZARDS

3.5.1. Batteries

The battery housing must be designed and constructed in such a way as to prevent the electrolyte being ejected on to the operator in the event of rollover or tipover and to avoid the accumulation of vapours in places occupied by operators.

Machinery must be designed and constructed in such a way that the battery can be disconnected with the aid of an easily accessible device provided for that purpose.

3.5.2. Fire

Depending on the hazards anticipated by the manufacturer, machinery must, where its size permits:

— either allow easily accessible fire extinguishers to be fitted, or

— be provided with built-in extinguisher systems.

3.5.3. Emissions of hazardous substances

The second and third paragraphs of section 1.5.13 do not apply where the main function of the machinery is the spraying of products. However, the operator must be protected against the risk of exposure to such hazardous emissions.

3.6. INFORMATION AND INDICATIONS

3.6.1. Signs, signals and warnings

All machinery must have signs and/or instruction plates concerning use, adjustment and maintenance, wherever necessary, so as to ensure the health and safety of persons. They must be chosen, designed and constructed in such a way as to be clearly visible and indelible.

Without prejudice to the provisions of road traffic regulations, machinery with a ride-on driver must have the following equipment:

— an acoustic warning device to alert persons,

—a system of light signals relevant to the intended conditions of use; the latter requirement does not apply to machinery intended solely for underground working and having no electrical power,

—where necessary, there must be an appropriate connection between a trailer and the machinery for the operation of signals.

Remote-controlled machinery which, under normal conditions of use, exposes persons to the risk of impact or crushing must be fitted with appropriate means to signal its movements or with means to protect persons against such risks. The same applies to machinery which involves, when in use, the constant repetition of a forward and backward movement on a single axis where the area to the rear of the machine is not directly visible to the driver.

Machinery must be constructed in such a way that the warning and signalling devices cannot be disabled unintentionally. Where it is essential for safety, such devices must be provided with the means to check that they are in good working order and their failure must be made apparent to the operator.

Where the movement of machinery or its tools is particularly hazardous, signs on the machinery must be provided to warn against approaching the machinery while it is working; the signs must be legible at a sufficient distance to ensure the safety of persons who have to be in the vicinity.

3.6.2. Marking

The following must be shown legibly and indelibly on all machinery:

— nominal power expressed in kilowatts (kW),

— mass of the most usual configuration, in kilograms (kg);

and, where appropriate:

— maximum drawbar pull provided for at the coupling hook, in Newtons (N),

— maximum vertical load provided for on the coupling hook, in Newtons (N).

3.6.3. Instructions

3.6.3.1. Vibrations

The instructions must give the following information concerning vibrations transmitted by the machinery to the hand-arm system or to the whole body:

—the vibration total value to which the hand-arm system is subjected, if it exceeds 2,5 m/s^2. Where this value does not exceed 2,5 m/s^2, this must be mentioned,

—the highest root mean square value of weighted acceleration to which the whole body is subjected, if it exceeds 0,5 m/s^2. Where this value does not exceed 0,5 m/s^2, this must be mentioned,

— the uncertainty of measurement.

These values must be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery which is representative of the machinery to be produced.

Where harmonised standards are not applied, the vibration must be measured using the most appropriate measurement code for the machinery concerned.

The operating conditions during measurement and the measurement codes used must be described.

3.6.3.2. Multiple uses

The instructions for machinery allowing several uses depending on the equipment used and the instructions for the interchangeable equipment must contain the information necessary for safe assembly and use of the basic machinery and the interchangeable equipment that can be fitted.

4. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET HAZARDS DUE TO LIFTING OPERATIONS

Machinery presenting hazards due to lifting operations must meet all the relevant essential health and safety requirements described in this chapter (see General Principles, point 4).

4.1. GENERAL

4.1.1. Definitions

(a)‘Lifting operation’ means a movement of unit loads consisting of goods and/or persons necessitating, at a given moment, a change of level.

(b)‘Guided load’ means a load where the total movement is made along rigid or flexible guides whose position is determined by fixed points.

(c)‘Working coefficient’ means the arithmetic ratio between the load guaranteed by the manufacturer or his authorised representative up to which a component is able to hold it and the maximum working load marked on the component.

(d)‘Test coefficient’ means the arithmetic ratio between the load used to carry out the static or dynamic tests on lifting machinery or a lifting accessory and the maximum working load marked on the lifting machinery or lifting accessory.

(e)‘Static test’ means the test during which lifting machinery or a lifting accessory is first inspected and subjected to a force corresponding to the maximum working load multiplied by the appropriate static test coefficient and then re-inspected once the said load has been released to ensure that no damage has occurred.

(f)‘Dynamic test’ means the test during which lifting machinery is operated in all its possible configurations at the maximum working load multiplied by the appropriate dynamic test coefficient with account being taken of the dynamic behaviour of the lifting machinery in order to check that it functions properly.

(g)‘Carrier’ means a part of the machinery on or in which persons and/or goods are supported in order to be lifted.

4.1.2. Protection against mechanical hazards

4.1.2.1. Risks due to lack of stability

Machinery must be designed and constructed in such a way that the stability required by section 1.3.1 is maintained both in service and out of service, including all stages of transportation, assembly and dismantling, during foreseeable component failures and also during the tests carried out in accordance with the instruction handbook. To that end, the manufacturer or his authorised representative must use the appropriate verification methods.

4.1.2.2. Machinery running on guide rails and rail tracks

Machinery must be provided with devices which act on the guide rails or tracks to prevent derailment.

If, despite such devices, there remains a risk of derailment or of failure of a rail or of a running component, devices must be provided which prevent the equipment, component or load from falling or the machinery from overturning.

4.1.2.3. Mechanical strength

Machinery, lifting accessories and their components must be capable of withstanding the stresses to which they are subjected, both in and, where applicable, out of use, under the installation and operating conditions provided for and in all relevant configurations, with due regard, where appropriate, to the effects of atmospheric factors and forces exerted by persons. This requirement must also be satisfied during transport, assembly and dismantling.

Machinery and lifting accessories must be designed and constructed in such a way as to prevent failure from fatigue and wear, taking due account of their intended use.

The materials used must be chosen on the basis of the intended working environments, with particular regard to corrosion, abrasion, impacts, extreme temperatures, fatigue, brittleness and ageing.

Machinery and lifting accessories must be designed and constructed in such a way as to withstand the overload in the static tests without permanent deformation or patent defect. Strength calculations must take account of the value of the static test coefficient chosen to guarantee an adequate level of safety. That coefficient has, as a general rule, the following values:

(a) manually-operated machinery and lifting accessories: 1,5;

(b) other machinery: 1,25.

Machinery must be designed and constructed in such a way as to undergo, without failure, the dynamic tests carried out using the maximum working load multiplied by the dynamic test coefficient. This dynamic test coefficient is chosen so as to guarantee an adequate level of safety: the coefficient is, as a general rule, equal to 1,1. As a general rule, the tests will be performed at the nominal speeds provided for. Should the control circuit of the machinery allow for a number of simultaneous movements, the tests must be carried out under the least favourable conditions, as a general rule by combining the movements concerned.

4.1.2.4. Pulleys, drums, wheels, ropes and chains

Pulleys, drums and wheels must have a diameter commensurate with the size of the ropes or chains with which they can be fitted.

Drums and wheels must be designed, constructed and installed in such a way that the ropes or chains with which they are equipped can be wound without coming off.

Ropes used directly for lifting or supporting the load must not include any splicing other than at their ends. Splicings are, however, tolerated in installations which are intended by design to be modified regularly according to needs of use.

Complete ropes and their endings must have a working coefficient chosen in such a way as to guarantee an adequate level of safety. As a general rule, this coefficient is equal to 5.

Lifting chains must have a working coefficient chosen in such a way as to guarantee an adequate level of safety. As a general rule, this coefficient is equal to 4.

In order to verify that an adequate working coefficient has been attained, the manufacturer or his authorised representative must, for each type of chain and rope used directly for lifting the load and for the rope ends, perform the appropriate tests or have such tests performed.

4.1.2.5. Lifting accessories and their components

Lifting accessories and their components must be sized with due regard to fatigue and ageing processes for a number of operating cycles consistent with their expected life-span as specified in the operating conditions for a given application.

Moreover:

(a)the working coefficient of wire-rope/rope-end combinations must be chosen in such a way as to guarantee an adequate level of safety; this coefficient is, as a general rule, equal to 5. Ropes must not comprise any splices or loops other than at their ends;

(b)where chains with welded links are used, they must be of the short-link type. The working coefficient of chains must be chosen in such a way as to guarantee an adequate level of safety; this coefficient is, as a general rule, equal to 4;

(c)the working coefficient for textile ropes or slings is dependent on the material, method of manufacture, dimensions and use. This coefficient must be chosen in such a way as to guarantee an adequate level of safety; it is, as a general rule, equal to 7, provided the materials used are shown to be of very good quality and the method of manufacture is appropriate to the intended use. Should this not be the case, the coefficient is, as a general rule, set at a higher level in order to secure an equivalent level of safety. Textile ropes and slings must not include any knots, connections or splicing other than at the ends of the sling, except in the case of an endless sling;

(d)all metallic components making up, or used with, a sling must have a working coefficient chosen in such a way as to guarantee an adequate level of safety; this coefficient is, as a general rule, equal to 4;

(e)the maximum working load of a multilegged sling is determined on the basis of the working coefficient of the weakest leg, the number of legs and a reduction factor which depends on the slinging configuration;

(f)in order to verify that an adequate working coefficient has been attained, the manufacturer or his authorised representative must, for each type of component referred to in (a), (b), (c) and (d), perform the appropriate tests or have such tests performed.

4.1.2.6. Control of movements

Devices for controlling movements must act in such a way that the machinery on which they are installed is kept safe.

(a)Machinery must be designed and constructed or fitted with devices in such a way that the amplitude of movement of its components is kept within the specified limits. The operation of such devices must, where appropriate, be preceded by a warning.

(b)Where several fixed or rail-mounted machines can be manoeuvred simultaneously in the same place, with risks of collision, such machinery must be designed and constructed in such a way as to make it possible to fit systems enabling these risks to be avoided.

(c)Machinery must be designed and constructed in such a way that the loads cannot creep dangerously or fall freely and unexpectedly, even in the event of partial or total failure of the power supply or when the operator stops operating the machine.

(d)It must not be possible, under normal operating conditions, to lower the load solely by friction brake, except in the case of machinery whose function requires it to operate in that way.

(e)Holding devices must be designed and constructed in such a way that inadvertent dropping of the loads is avoided.

4.1.2.7. Movements of loads during handling

The operating position of machinery must be located in such a way as to ensure the widest possible view of trajectories of the moving parts, in order to avoid possible collisions with persons, equipment or other machinery which might be manoeuvring at the same time and liable to constitute a hazard.

Machinery with guided loads must be designed and constructed in such a way as to prevent persons from being injured by movement of the load, the carrier or the counterweights, if any.

4.1.2.8. Machinery serving fixed landings

4.1.2.8.1. Movements of the carrier

The movement of the carrier of machinery serving fixed landings must be rigidly guided to and at the landings. Scissor systems are also regarded as rigid guidance.

4.1.2.8.2. Access to the carrier

Where persons have access to the carrier, the machinery must be designed and constructed in such a way as to ensure that the carrier remains stationary during access, in particular while it is being loaded or unloaded.

The machinery must be designed and constructed in such a way as to ensure that the difference in level between the carrier and the landing being served does not create a risk of tripping.

4.1.2.8.3. Risks due to contact with the moving carrier

Where necessary in order to fulfil the requirement expressed in the second paragraph of section 4.1.2.7, the travel zone must be rendered inaccessible during normal operation.

When, during inspection or maintenance, there is a risk that persons situated under or above the carrier may be crushed between the carrier and any fixed parts, sufficient free space must be provided either by means of physical refuges or by means of mechanical devices blocking the movement of the carrier.

4.1.2.8.4. Risk due to the load falling off the carrier

Where there is a risk due to the load falling off the carrier, the machinery must be designed and constructed in such a way as to prevent this risk.

4.1.2.8.5. Landings

Risks due to contact of persons at landings with the moving carrier or other moving parts must be prevented.

Where there is a risk due to persons falling into the travel zone when the carrier is not present at the landings, guards must be fitted in order to prevent this risk. Such guards must not open in the direction of the travel zone. They must be fitted with an interlocking device controlled by the position of the carrier that prevents:

— hazardous movements of the carrier until the guards are closed and locked,

— hazardous opening of a guard until the carrier has stopped at the corresponding landing.

4.1.3. Fitness for purpose

When lifting machinery or lifting accessories are placed on the market or are first put into service, the manufacturer or his authorised representative must ensure, by taking appropriate measures or having them taken, that the machinery or the lifting accessories which are ready for use — whether manually or power-operated — can fulfil their specified functions safely.

The static and dynamic tests referred to in section 4.1.2.3 must be performed on all lifting machinery ready to be put into service.

Where the machinery cannot be assembled in the manufacturer's premises or in the premises of his authorised representative, the appropriate measures must be taken at the place of use. Otherwise, the measures may be taken either in the manufacturer's premises or at the place of use.

4.2. REQUIREMENTS FOR MACHINERY WHOSE POWER SOURCE IS OTHER THAN MANUAL EFFORT

4.2.1. Control of movements

Hold-to-run control devices must be used to control the movements of the machinery or its equipment. However, for partial or complete movements in which there is no risk of the load or the machinery colliding, the said devices may be replaced by control devices authorising automatic stops at pre-selected positions without the operator holding a hold-to-run control device.

4.2.2. Loading control

Machinery with a maximum working load of not less than 1 000 kilograms or an overturning moment of not less than 40 000 Nm must be fitted with devices to warn the driver and prevent dangerous movements in the event:

— of overloading, either as a result of the maximum working load or the maximum working moment due to the load being exceeded, or

— of the overturning moment being exceeded.

4.2.3. Installations guided by ropes

Rope carriers, tractors or tractor carriers must be held by counterweights or by a device allowing permanent control of the tension.

4.3. INFORMATION AND MARKINGS

4.3.1. Chains, ropes and webbing

Each length of lifting chain, rope or webbing not forming part of an assembly must bear a mark or, where this is not possible, a plate or irremovable ring bearing the name and address of the manufacturer or his authorised representative and the identifying reference of the relevant certificate.

The certificate mentioned above must show at least the following information:

(a) the name and address of the manufacturer and, if appropriate, his authorised representative;

(b) a description of the chain or rope which includes:

— its nominal size,

— its construction,

— the material from which it is made, and

— any special metallurgical treatment applied to the material;

(c) the test method used;

(d)the maximum load to which the chain or rope should be subjected in service. A range of values may be given on the basis of the intended applications.

4.3.2. Lifting accessories

Lifting accessories must show the following particulars:

— identification of the material where this information is needed for safe use,

— the maximum working load.

In the case of lifting accessories on which marking is physically impossible, the particulars referred to in the first paragraph must be displayed on a plate or other equivalent means and securely affixed to the accessory.

The particulars must be legible and located in a place where they are not liable to disappear as a result of wear or jeopardise the strength of the accessory.

4.3.3. Lifting machinery

The maximum working load must be prominently marked on the machinery. This marking must be legible, indelible and in an un-coded form.

Where the maximum working load depends on the configuration of the machinery, each operating position must be provided with a load plate indicating, preferably in diagrammatic form or by means of tables, the working load permitted for each configuration.

Machinery intended for lifting goods only, equipped with a carrier which allows access to persons, must bear a clear and indelible warning prohibiting the lifting of persons. This warning must be visible at each place where access is possible.

4.4. INSTRUCTIONS

4.4.1. Lifting accessories

Each lifting accessory or each commercially indivisible batch of lifting accessories must be accompanied by instructions setting out at least the following particulars:

(a) the intended use;

(b)the limits of use (particularly for lifting accessories such as magnetic or vacuum pads which do not fully comply with section 4.1.2.6(e));

(c) instructions for assembly, use and maintenance;

(d) the static test coefficient used.

4.4.2. Lifting machinery

Lifting machinery must be accompanied by instructions containing information on:

(a)the technical characteristics of the machinery, and in particular:

—the maximum working load and, where appropriate, a copy of the load plate or load table described in the second paragraph of section 4.3.3,

— the reactions at the supports or anchors and, where appropriate, characteristics of the tracks,

— where appropriate, the definition and the means of installation of the ballast;

(b) the contents of the logbook, if the latter is not supplied with the machinery;

(c) advice for use, particularly to offset the lack of direct vision of the load by the operator;

(d)where appropriate, a test report detailing the static and dynamic tests carried out by or for the manufacturer or his authorised representative;

(e)for machinery which is not assembled on the premises of the manufacturer in the form in which it is to be used, the necessary instructions for performing the measures referred to in section 4.1.3 before it is first put into service.

5. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR MACHINERY INTENDED FOR UNDERGROUND WORK

Machinery intended for underground work must meet all the essential health and safety requirements described in this chapter (see General Principles, point 4).

5.1. RISKS DUE TO LACK OF STABILITY

Powered roof supports must be designed and constructed in such a way as to maintain a given direction when moving and not slip before and while they come under load and after the load has been removed. They must be equipped with anchorages for the top plates of the individual hydraulic props.

5.2. MOVEMENT

Powered roof supports must allow for unhindered movement of persons.

5.3. CONTROL DEVICES

The accelerator and brake controls for movement of machinery running on rails must be hand-operated. However, enabling devices may be foot-operated.

The control devices of powered roof supports must be designed and positioned in such a way that, during displacement operations, operators are sheltered by a support in place. The control devices must be protected against any accidental release.

5.4. STOPPING

Self-propelled machinery running on rails for use in underground work must be equipped with an enabling device acting on the circuit controlling the movement of the machinery such that movement is stopped if the driver is no longer in control of the movement.

5.5. FIRE

The second indent of section 3.5.2 is mandatory in respect of machinery which comprises highly flammable parts.

The braking system of machinery intended for use in underground workings must be designed and constructed in such a way that it does not produce sparks or cause fires.

Machinery with internal combustion engines for use in underground workings must be fitted only with engines using fuel with a low vaporising pressure and which exclude any spark of electrical origin.

5.6. EXHAUST EMISSIONS

Exhaust emissions from internal combustion engines must not be discharged upwards.

6. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR MACHINERY PRESENTING PARTICULAR HAZARDS DUE TO THE LIFTING OF PERSONS

Machinery presenting hazards due to the lifting of persons must meet all the relevant essential health and safety requirements described in this chapter (see General Principles, point 4).

6.1. GENERAL

6.1.1. Mechanical strength

The carrier, including any trapdoors, must be designed and constructed in such a way as to offer the space and strength corresponding to the maximum number of persons permitted on the carrier and the maximum working load.

The working coefficients for components set out in sections 4.1.2.4 and 4.1.2.5 are inadequate for machinery intended for the lifting of persons and must, as a general rule, be doubled. Machinery intended for lifting persons or persons and goods must be fitted with a suspension or supporting system for the carrier designed and constructed in such a way as to ensure an adequate overall level of safety and to prevent the risk of the carrier falling.

If ropes or chains are used to suspend the carrier, as a general rule, at least two independent ropes or chains are required, each with its own anchorage.

6.1.2. Loading control for machinery moved by power other than human strength

The requirements of section 4.2.2 apply regardless of the maximum working load and overturning moment, unless the manufacturer can demonstrate that there is no risk of overloading or overturning.

6.2. CONTROL DEVICES

Where safety requirements do not impose other solutions, the carrier must, as a general rule, be designed and constructed in such a way that persons in the carrier have means of controlling upward and downward movements and, if appropriate, other movements of the carrier.

In operation, those control devices must override any other devices controlling the same movement with the exception of emergency stop devices.

The control devices for these movements must be of the hold-to-run type except where the carrier itself is completely enclosed.

6.3. RISKS TO PERSONS IN OR ON THE CARRIER

6.3.1. Risks due to movements of the carrier

Machinery for lifting persons must be designed, constructed or equipped in such a way that the acceleration or deceleration of the carrier does not engender risks for persons.

6.3.2. Risk of persons falling from the carrier

The carrier must not tilt to an extent which creates a risk of the occupants falling, including when the machinery and carrier are moving.

Where the carrier is designed as a work station, provision must be made to ensure stability and to prevent hazardous movements.

If the measures referred to in section 1.5.15 are not adequate, carriers must be fitted with a sufficient number of suitable anchorage points for the number of persons permitted on the carrier. The anchorage points must be strong enough for the use of personal protective equipment against falls from a height.

Any trapdoor in floors or ceilings or side doors must be designed and constructed in such a way as to prevent inadvertent opening and must open in a direction that obviates any risk of falling, should they open unexpectedly.

6.3.3. Risk due to objects falling on the carrier

Where there is a risk of objects falling on the carrier and endangering persons, the carrier must be equipped with a protective roof.

6.4. MACHINERY SERVING FIXED LANDINGS

6.4.1. Risks to persons in or on the carrier

The carrier must be designed and constructed in such a way as to prevent risks due to contact between persons and/or objects in or on the carrier with any fixed or moving elements. Where necessary in order to fulfil this requirement, the carrier itself must be completely enclosed with doors fitted with an interlocking device that prevents hazardous movements of the carrier unless the doors are closed. The doors must remain closed if the carrier stops between landings where there is a risk of falling from the carrier.

The machinery must be designed, constructed and, where necessary, equipped with devices in such a way as to prevent uncontrolled upward or downward movement of the carrier. These devices must be able to stop the carrier at its maximum working load and at the foreseeable maximum speed.

The stopping action must not cause deceleration harmful to the occupants, whatever the load conditions.

6.4.2. Controls at landings

Controls, other than those for emergency use, at landings must not initiate movements of the carrier when:

— the control devices in the carrier are being operated,

— the carrier is not at a landing.

6.4.3. Access to the carrier

The guards at the landings and on the carrier must be designed and constructed in such a way as to ensure safe transfer to and from the carrier, taking into consideration the foreseeable range of goods and persons to be lifted.

6.5. MARKINGS

The carrier must bear the information necessary to ensure safety including:

— the number of persons permitted on the carrier,

— the maximum working load.

ANNEX II

Declarations

1. CONTENT

A. EC DECLARATION OF CONFORMITY OF THE MACHINERY

This declaration and translations thereof must be drawn up under the same conditions as the instructions (see Annex I, section 1.7.4.1(a) and (b)), and must be typewritten or else handwritten in capital letters.

This declaration relates exclusively to the machinery in the state in which it was placed on the market, and excludes components which are added and/or operations carried out subsequently by the final user.

The EC declaration of conformity must contain the following particulars:

1. business name and full address of the manufacturer and, where appropriate, his authorised representative;
2. name and address of the person authorised to compile the technical file, who must be established in the Community;
3. description and identification of the machinery, including generic denomination, function, model, type, serial number and commercial name;
4. a sentence expressly declaring that the machinery fulfils all the relevant provisions of this Directive and where appropriate, a similar sentence declaring the conformity with other Directives and/or relevant provisions with which the machinery complies. These references must be those of the texts published in the *Official Journal of the European Union;*
5. where appropriate, the name, address and identification number of the notified body which carried out the EC type-examination referred to in Annex IX and the number of the EC type-examination certificate;
6. where appropriate, the name, address and identification number of the notified body which approved the full quality assurance system referred to in Annex X;

7. where appropriate, a reference to the harmonised standards used, as referred to in Article 7(2);

8. where appropriate, the reference to other technical standards and specifications used;

9. the place and date of the declaration;

10. the identity and signature of the person empowered to draw up the declaration on behalf of the manufacturer or his authorised representative.

B. DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

This declaration and translations thereof must be drawn up under the same conditions as the instructions (see Annex 1, section 1.7.4.1(a) and (b)), and must be typewritten or else handwritten in capital letters.

The declaration of incorporation must contain the following particulars:

1. business name and full address of the manufacturer of the partly completed machinery and, where appropriate, his authorised representative;

2. name and address of the person authorised to compile the relevant technical documentation, who must be established in the Community;

3. description and identification of the partly completed machinery including generic denomination, function, model, type, serial number and commercial name;

4. a sentence declaring which essential requirements of this Directive are applied and fulfilled and that the relevant technical documentation is compiled in accordance with part B of Annex VII, and, where appropriate, a sentence declaring the conformity of the partly completed machinery with other relevant Directives. These references must be those of the texts published in the *Official Journal of the European Union;*

5. an undertaking to transmit, in response to a reasoned request by the national authorities, relevant information on the partly completed machinery. This shall include the method of transmission and shall be without prejudice to the intellectual property rights of the manufacturer of the partly completed machinery;

6. a statement that the partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of this Directive, where appropriate;

7. the place and date of the declaration;

8. the identity and signature of the person empowered to draw up the declaration on behalf of the manufacturer or his authorised representative.

2. CUSTODY

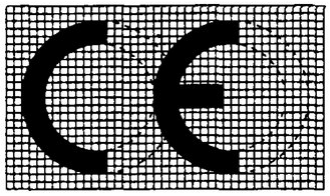
The manufacturer of machinery or his authorised representative shall keep the original EC declaration of conformity for a period of at least 10 years from the last date of manufacture of the machinery.

The manufacturer of partly completed machinery or his authorised representative shall keep the original declaration of incorporation for a period of at least 10 years from the last date of manufacture of the partly completed machinery.

ANNEX III

CE marking

The CE conformity marking shall consist of the initials ‘CE’ taking the following form:



If the CE marking is reduced or enlarged the proportions shown in the above drawing must be respected.

The various components of the CE marking must have substantially the same vertical dimension, which may not be less than 5 mm. The minimum dimension may be waived for small-scale machinery.

The CE marking must be affixed in the immediate vicinity of the name of the manufacturer or his authorised representative, using the same technique.

Where the full quality assurance procedure referred to in Article 12(3)(c) and 12(4)(b) has been applied, the CE marking must be followed by the identification number of the notified body.

ANNEX IV

Categories of machinery to which one of the procedures referred to in Article 12(3) and (4) must be applied

1.

Circular saws (single- or multi-blade) for working with wood and material with similar physical characteristics or for working with meat and material with similar physical characteristics, of the following types:

1.1. sawing machinery with fixed blade(s) during cutting, having a fixed bed or support with manual feed of the workpiece or with a demountable power feed;

1.2. sawing machinery with fixed blade(s) during cutting, having a manually operated reciprocating saw-bench or carriage;

1.3 sawing machinery with fixed blade(s) during cutting, having a built-in mechanical feed device for the workpieces, with manual loading and/or unloading;

1.4. sawing machinery with movable blade(s) during cutting, having mechanical movement of the blade, with manual loading and/or unloading.

2.

Hand-fed surface planing machinery for woodworking.

3.

Thicknessers for one-side dressing having a built-in mechanical feed device, with manual loading and/or unloading for woodworking.

4.

Band-saws with manual loading and/or unloading for working with wood and material with similar physical characteristics or for working with meat and material with similar physical characteristics, of the following types:

4.1. sawing machinery with fixed blade(s) during cutting, having a fixed or reciprocating-movement bed or support for the workpiece;

4.2. sawing machinery with blade(s) assembled on a carriage with reciprocating motion.

5.

Combined machinery of the types referred to in points 1 to 4 and in point 7 for working with wood and material with similar physical characteristics.

6.

Hand-fed tenoning machinery with several tool holders for woodworking.

7.

Hand-fed vertical spindle moulding machinery for working with wood and material with similar physical characteristics.

8.

Portable chainsaws for woodworking.

9.

Presses, including press-brakes, for the cold working of metals, with manual loading and/or unloading, whose movable working parts may have a travel exceeding 6 mm and a speed exceeding 30 mm/s.

10.

Injection or compression plastics-moulding machinery with manual loading or unloading.

11.

Injection or compression rubber-moulding machinery with manual loading or unloading.

12.

Machinery for underground working of the following types:

12.1. locomotives and brake-vans;

12.2. hydraulic-powered roof supports.

13.

Manually loaded trucks for the collection of household refuse incorporating a compression mechanism.

14.

Removable mechanical transmission devices including their guards.

15.

Guards for removable mechanical transmission devices.

16.

Vehicle servicing lifts.

17.

Devices for the lifting of persons or of persons and goods involving a hazard of falling from a vertical height of more than three metres.

18.

Portable cartridge-operated fixing and other impact machinery.

19.

Protective devices designed to detect the presence of persons.

20.

Power-operated interlocking movable guards designed to be used as safeguards in machinery referred to in points 9, 10 and 11.

21.

Logic units to ensure safety functions.

22.

Roll-over protective structures (ROPS).

23.

Falling-object protective structures (FOPS).

ANNEX V

Indicative list of the safety components referred to in Article 2(c)

1.

Guards for removable mechanical transmission devices.

2.

Protective devices designed to detect the presence of persons.

3.

Power-operated interlocking movable guards designed to be used as safeguards in machinery referred to in items 9, 10 and 11 of Annex IV.

4.

Logic units to ensure safety functions.

5.

Valves with additional means for failure detection intended for the control of dangerous movements on machinery.

6.

Extraction systems for machinery emissions.

7.

Guards and protective devices designed to protect persons against moving parts involved in the process on the machinery.

8.

Monitoring devices for loading and movement control in lifting machinery.

9.

Restraint systems to keep persons on their seats.

10.

Emergency stop devices.

11.

Discharging systems to prevent the build-up of potentially dangerous electrostatic charges.

12.

Energy limiters and relief devices referred to in sections 1.5.7, 3.4.7 and 4.1.2.6 of Annex I.

13.

Systems and devices to reduce the emission of noise and vibrations.

14.

Roll-over protective structures (ROPS).

15.

Falling-object protective structures (FOPS).

16.

Two-hand control devices.

17. Components for machinery designed for lifting and/or lowering persons between different landings and included in the following list:

(a) devices for locking landing doors;

(b) devices to prevent the load-carrying unit from falling or unchecked upwards movement;

(c) overspeed limitation devices;

(d) energy-accumulating shock absorbers,

— non-linear, or

— with damping of the return movement;

(e) energy-dissipating shock absorbers;

(f)safety devices fitted to jacks of hydraulic power circuits where these are used as devices to prevent falls;

(g) electric safety devices in the form of safety switches containing electronic components.

ANNEX VI

Assembly instructions for partly completed machinery

The assembly instructions for partly completed machinery must contain a description of the conditions which must be met with a view to correct incorporation in the final machinery, so as not to compromise safety and health.

The assembly instructions must be written in an official Community language acceptable to the manufacturer of the machinery in which the partly completed machinery will be assembled, or to his authorised representative.

ANNEX VII

A. Technical file for machinery

This part describes the procedure for compiling a technical file. The technical file must demonstrate that the machinery complies with the requirements of this Directive. It must cover the design, manufacture and operation of the machinery to the extent necessary for this assessment. The technical file must be compiled in one or more official Community languages, except for the instructions for the machinery, for which the special provisions of Annex I, section 1.7.4.1 apply.

1. The technical file shall comprise the following:

(a)a construction file including:

— a general description of the machinery,

—the overall drawing of the machinery and drawings of the control circuits, as well as the pertinent descriptions and explanations necessary for understanding the operation of the machinery,

—full detailed drawings, accompanied by any calculation notes, test results, certificates, etc., required to check the conformity of the machinery with the essential health and safety requirements,

—the documentation on risk assessment demonstrating the procedure followed, including:

(i) a list of the essential health and safety requirements which apply to the machinery,

(ii)the description of the protective measures implemented to eliminate identified hazards or to reduce risks and, when appropriate, the indication of the residual risks associated with the machinery,

—the standards and other technical specifications used, indicating the essential health and safety requirements covered by these standards,

—any technical report giving the results of the tests carried out either by the manufacturer or by a body chosen by the manufacturer or his authorised representative,

— a copy of the instructions for the machinery,

—where appropriate, the declaration of incorporation for included partly completed machinery and the relevant assembly instructions for such machinery,

—where appropriate, copies of the EC declaration of conformity of machinery or other products incorporated into the machinery,

— a copy of the EC declaration of conformity;

(b)for series manufacture, the internal measures that will be implemented to ensure that the machinery remains in conformity with the provisions of this Directive.

The manufacturer must carry out necessary research and tests on components, fittings or the completed machinery to determine whether by its design or construction it is capable of being assembled and put into service safely. The relevant reports and results shall be included in the technical file.

2. The technical file referred to in point 1 must be made available to the competent authorities of the Member States for at least 10 years following the date of manufacture of the machinery or, in the case of series manufacture, of the last unit produced.

The technical file does not have to be located in the territory of the Community, nor does it have to be permanently available in material form. However, it must be capable of being assembled and made available within a period of time commensurate with its complexity by the person designated in the EC declaration of conformity.

The technical file does not have to include detailed plans or any other specific information as regards the sub-assemblies used for the manufacture of the machinery unless a knowledge of them is essential for verification of conformity with the essential health and safety requirements.

3. Failure to present the technical file in response to a duly reasoned request by the competent national authorities may constitute sufficient grounds for doubting the conformity of the machinery in question with the essential health and safety requirements.

B. Relevant technical documentation for partly completed machinery

This part describes the procedure for compiling relevant technical documentation. The documentation must show which requirements of this Directive are applied and fulfilled. It must cover the design, manufacture and operation of the partly completed machinery to the extent necessary for the assessment of conformity with the essential health and safety requirements applied. The documentation must be compiled in one or more official Community languages.

It shall comprise the following:

(a)a construction file including:

— the overall drawing of the partly completed machinery and drawings of the control circuits,

— full detailed drawings, accompanied by any calculation notes, test results, certificates, etc., required to check the conformity of the partly completed machinery with the applied essential health and safety requirements,

— the risk assessment documentation showing the procedure followed, including:

(i) a list of the essential health and safety requirements applied and fulfilled,

(ii) the description of the protective measures implemented to eliminate identified hazards or to reduce risks and, where appropriate, the indication of the residual risks,

(iii) the standards and other technical specifications used, indicating the essential health and safety requirements covered by these standards,

(iv) any technical report giving the results of the tests carried out either by the manufacturer or by a body chosen by the manufacturer or his authorised representative,

(v) a copy of the assembly instructions for the partly completed machinery;

(b) for series manufacture, the internal measures that will be implemented to ensure that the partly completed machinery remains in conformity with the essential health and safety requirements applied.

The manufacturer must carry out necessary research and tests on components, fittings or the partly completed machinery to determine whether by its design or construction it is capable of being assembled and used safely. The relevant reports and results shall be included in the technical file.

The relevant technical documentation must be available for at least 10 years following the date of manufacture of the partly completed machinery or, in the case of series manufacture, of the last unit produced, and on request presented to the competent authorities of the Member States. It does not have to be located in the territory of the Community, nor does it have to be permanently available in material form. It must be capable of being assembled and presented to the relevant authority by the person designated in the declaration for incorporation.

Failure to present the relevant technical documentation in response to a duly reasoned request by the competent national authorities may constitute sufficient grounds for doubting the conformity of the partly completed machinery with the essential health and safety requirements applied and attested.

ANNEX VIII

Assessment of conformity with internal checks on the manufacture of machinery

1.

This Annex describes the procedure by which the manufacturer or his authorised representative, who carries out the obligations laid down in points 2 and 3, ensures and declares that the machinery concerned satisfies the relevant requirements of this Directive.

2.

For each representative type of the series in question, the manufacturer or his authorised representative shall draw up the technical file referred to in Annex VII, part A.

3.

The manufacturer must take all measures necessary in order that the manufacturing process ensures compliance of the manufactured machinery with the technical file referred to in Annex VII, part A, and with the requirements of this Directive.

ANNEX IX

EC type-examination

EC type-examination is the procedure whereby a notified body ascertains and certifies that a representative model of machinery referred to in Annex IV (hereafter named the type) satisfies the provisions of this Directive.

1.

The manufacturer or his authorised representative must, for each type, draw up the technical file referred to in Annex VII, part A.

2.

For each type, the application for an EC type-examination shall be submitted by the manufacturer or his authorised representative to a notified body of his choice.

The application shall include:

— the name and address of the manufacturer and, where appropriate, his authorised representative,

— a written declaration that the application has not been submitted to another notified body,

— the technical file.

Moreover, the applicant shall place at the disposal of the notified body a sample of the type. The notified body may ask for further samples if the test programme so requires.

3.

The notified body shall:

3.1. examine the technical file, check that the type was manufactured in accordance with it and establish which elements have been designed in accordance with the relevant provisions of the standards referred to in Article 7(2), and those elements whose design is not based on the relevant provisions of those standards;

3.2. carry out or have carried out appropriate inspections, measurements and tests to ascertain whether the solutions adopted satisfy the essential health and safety requirements of this Directive, where the standards referred to in Article 7(2) were not applied;

3.3. where harmonised standards referred to in Article 7(2) were used, carry out or have carried out appropriate inspections, measurements and tests to verify that those standards were actually applied;

3.4. agree with the applicant as to the place where the check that the type was manufactured in accordance with the examined technical file and the necessary inspections, measurements and tests will be carried out.

4.

If the type satisfies the provisions of this Directive, the notified body shall issue the applicant with an EC type-examination certificate. The certificate shall include the name and address of the manufacturer and his authorised representative, the data necessary for identifying the approved type, the conclusions of the examination and the conditions to which its issue may be subject.

The manufacturer and the notified body shall retain a copy of this certificate, the technical file and all relevant documents for a period of 15 years from the date of issue of the certificate.

5.

If the type does not satisfy the provisions of this Directive, the notified body shall refuse to issue the applicant with an EC type-examination certificate, giving detailed reasons for its refusal. It shall inform the applicant, the other notified bodies and the Member State which notified it. An appeal procedure must be available.

6.

The applicant shall inform the notified body which retains the technical file relating to the EC type-examination certificate of all modifications to the approved type. The notified body shall examine these modifications and shall then either confirm the validity of the existing EC type-examination certificate or issue a new one if the modifications are liable to compromise conformity with the essential health and safety requirements or the intended working conditions of the type.

7.

The Commission, the Member States and the other notified bodies may, on request, obtain a copy of the EC type-examination certificates. On reasoned request, the Commission and the Member States may obtain a copy of the technical file and the results of the examinations carried out by the notified body.

8.

Files and correspondence referring to the EC type-examination procedures shall be written in the official Community language(s) of the Member State where the notified body is established or in any other official Community language acceptable to the notified body.

9.

Validity of the EC type-examination certificate

9.1.

The notified body has the ongoing responsibility of ensuring that the EC type-examination certificate remains valid. It shall inform the manufacturer of any major changes which would have an implication on the validity of the certificate. The notified body shall withdraw certificates which are no longer valid.

9.2.

The manufacturer of the machinery concerned has the ongoing responsibility of ensuring that the said machinery meets the corresponding state of the art.

9.3.

The manufacturer shall request from the notified body the review of the validity of the EC type-examination certificate every five years.

If the notified body finds that the certificate remains valid, taking into account the state of the art, it shall renew the certificate for a further five years.

The manufacturer and the notified body shall retain a copy of this certificate, of the technical file and of all the relevant documents for a period of 15 years from the date of issue of the certificate.

9.4.

In the event that the validity of the EC-type examination certificate is not renewed, the manufacturer shall cease the placing on the market of the machinery concerned.

ANNEX X

Full quality assurance

This Annex describes the conformity assessment of machinery referred to in Annex IV, manufactured using a full quality assurance system, and the procedure whereby a notified body assesses and approves the quality system and monitors its application.

1.

The manufacturer must operate an approved quality system for design, manufacture, final inspection and testing, as specified in point 2, and shall be subject to the surveillance referred to in point 3.

2.

Quality system

2.1.

The manufacturer or his authorised representative shall lodge an application for assessment of his quality system to a notified body of his choice.

The application shall contain:

— the name and address of the manufacturer and, where appropriate, his authorised representative,

— the places of design, manufacture, inspection, testing and storage of the machinery,

— the technical file described in Annex VII, Part A, for one model of each category of machinery referred to in Annex IV which he intends to manufacture,

— the documentation on the quality system,

— a written declaration that the application has not been submitted to another notified body.

2.2.

The quality system must ensure conformity of the machinery with the provisions of this Directive. All the elements, requirements and provisions adopted by the manufacturer must be documented in a systematic and orderly manner, in the form of measures, procedures and written instructions. The documentation on the quality system must permit a uniform interpretation of the procedural and quality measures, such as quality programmes, plans, manuals and records.

It must contain, in particular, an adequate description of:

—the quality objectives, the organisational structure, and the responsibilities and powers of the management with regard to the design and quality of the machinery,

—the technical design specifications, including standards that will be applied and, where the standards referred to in Article 7(2) are not applied in full, the means that will be used to ensure that the essential health and safety requirements of this Directive are fulfilled,

—the design inspection and design verification techniques, processes and systematic actions that will be used when designing machinery covered by this Directive,

—the corresponding manufacturing, quality control and quality assurance techniques, processes and systematic actions that will be used,

—the inspections and tests that will be carried out before, during and after manufacture, and the frequency with which they will be carried out,

—the quality records, such as inspection reports and test data, calibration data, and reports on the qualifications of the personnel concerned,

—the means of monitoring the achievement of the required design and quality of the machinery, as well as the effective operation of the quality system.

2.3.

The notified body shall assess the quality system to determine whether it satisfies the requirements of point 2.2.

The elements of the quality system which conform to the relevant harmonised standard shall be presumed to conform to the corresponding requirements referred to in point 2.2.

The team of auditors must have at least one member who is experienced in the assessment of the technology of the machinery. The assessment procedure shall include an inspection to be carried out at the manufacturer's premises. During the assessment, the team of auditors shall carry out a review of the technical files referred to in point 2.1, second paragraph, third indent to ensure their compliance with the relevant health and safety requirements.

The manufacturer or his authorised representative shall be notified of the decision. The notification shall contain the conclusions of the examination and the reasoned assessment decision. An appeal procedure must be available.

2.4.

The manufacturer shall undertake to fulfil the obligations arising from the quality system as approved and to ensure that it remains appropriate and effective.

The manufacturer or his authorised representative shall inform the notified body which approved the quality system of any planned change to it.

The notified body shall evaluate the proposed changes and decide whether the modified quality assurance system will continue to satisfy the requirements referred to in point 2.2, or whether a re-assessment is necessary.

It shall notify the manufacturer of its decision. The notification shall contain the conclusions of the examination and the reasoned assessment decision.

3.

Surveillance under the responsibility of the notified body

3.1.

The purpose of surveillance is to make sure that the manufacturer duly fulfils the obligations arising out of the approved quality system.

3.2.
The manufacturer shall, for inspection purposes, allow the notified body access to the places of design, manufacture, inspection, testing and storage, and shall provide it with all necessary information, such as:

— the documentation concerning the quality system,

—the quality records provided for in that part of the quality system concerned with design, such as the results of analyses, calculations, tests, etc.,

—the quality records provided for in that part of the quality system concerned with manufacture, such as inspection reports and test data, calibration data, reports on the qualifications of the personnel concerned, etc.

3.3.

The notified body shall conduct periodic audits to make sure that the manufacturer is maintaining and applying the quality system; it shall provide the manufacturer with an audit report. The frequency of the periodic audits shall be such that a full reassessment is carried out every three years.

3.4.
Moreover, the notified body may pay the manufacturer unannounced visits. The need for these additional visits and their frequency will be determined on the basis of a visit monitoring system managed by the notified body. In particular, the following factors will be taken into account in the visits monitoring system:

— the results of previous surveillance visits,

— the need to monitor remedial measures,

— where appropriate, special conditions attaching to approval of the system,

—significant modifications in the organisation of the manufacturing process, measures or techniques.

On the occasion of such visits, the notified body may, if necessary, carry out tests or have them carried out in order to check the proper functioning of the quality system. It shall provide the manufacturer with a visit report and, if a test was carried out, with a test report.

4.
The manufacturer or his authorised representative shall keep available for the national authorities, for a period of ten years from the last date of manufacture:

— the documentation referred to in point 2.1,

—the decisions and reports of the notified body referred to in point 2.4, third and fourth subparagraphs, and in points 3.3 and 3.4.

ANNEX XI

Minimum criteria to be taken into account by Member States for the notification of bodies

1.

The body, its director and the staff responsible for carrying out the verification tests shall not be the designer, manufacturer, supplier or installer of machines which they inspect, nor the authorised representative of any of these parties. They shall not become involved, either directly or as authorised representatives, in the design, construction, marketing or maintenance of the machines. This does not preclude the possibility of exchanges of technical information between the manufacturer and the body.

2.

The body and its staff shall carry out the verification tests with the highest degree of professional integrity and technical competence and shall be free from all pressures and inducements, particularly financial, which might influence their judgement or the results of the inspection, especially from persons or groups of persons with an interest in the result of verifications.

3.

For each category of machinery for which it is notified, the body must possess personnel with technical knowledge and sufficient and appropriate experience to perform a conformity assessment. It must have the means necessary to complete the technical and administrative tasks connected with implementation of the checks in an appropriate manner; it must also have access to the equipment necessary for the exceptional checks.

4.
The staff responsible for inspection shall have:

— sound technical and vocational training,

—satisfactory knowledge of the requirements of the tests they carry out and adequate experience of such tests,

—the ability to draw up the certificates, records and reports required to authenticate the performance of the tests.

5.

The impartiality of inspection staff shall be guaranteed. Their remuneration shall not depend on the number of tests carried out or on the results of such tests.

6.

The body shall take out liability insurance unless its liability is assumed by the State in accordance with national law, or the Member State itself is directly responsible for the tests.

7.

The staff of the body shall be bound to observe professional secrecy with regard to all information obtained in carrying out its tasks (except vis-à-vis the competent administrative authorities of the State in which its activities are carried out) under this Directive or any provision of national law giving effect to it.

8.

Notified bodies shall participate in coordination activities. They shall also take part directly or be represented in European standardisation, or ensure that they know the situation in respect of relevant standards.

9.

Member States may take all necessary measures they regard as necessary in order to ensure that, in the event of cessation of the activities of a notified body, the files of its customers are sent to another body or are made available to the Member State which has notified it.

ANNEX XII

Correlation table [1]

Directive 98/37/EC	This Directive
Article 1(1)	Article 1(1)
Article 1(2)(a)	Article 2(a) and (b)
Article 1(2)(b)	Article 2(c)
Article 1(3)	Article 1(2)
Article 1(4)	Article 3
Article 1(5)	—
Article 2(1)	Article 4(1)
Article 2(2)	Article 15
Article 2(3)	Article 6(3)
Article 3	Article 5(1)(a)
Article 4(1)	Article 6(1)
Article 4(2), first subparagraph	Article 6(2)
Article 4(2), second subparagraph	—
Article 4(3)	—
Article 5(1), first subparagraph	Article 7(1)
Article 5(1), second subparagraph	—
Article 5(2), first subparagraph	Article 7(2) and (3)
Article 5(2), last subparagraph	—
Article 5(3)	Article 7(4)
Article 6(1)	Article 10
Article 6(2)	Article 22
Article 7(1)	Article 11(1) and (2)
Article 7(2)	Article 11(3) and (4)

Article 7(3)	Article 11(4)
Article 7(4)	Article 11(5)
Article 8(1), first subparagraph	Article 5(1)(e) and Article 12(1)
Article 8(1), second subparagraph	Article 5(1)(f)
Article 8(2)(a)	Article 12(2)
Article 8(2)(b)	Article 12(4)
Article 8(2)(c)	Article 12(3)
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Article 8(4)	—
Article 8(5)	—
Article 8(6)	Article 5(4)
Article 8(7)	—
Article 8(8)	—
Article 9(1), first subparagraph	Article 14(1)
Article 9(1), second subparagraph	Article 14(4)
Article 9(2)	Article 14(3) and (5)
Article 9(3)	Article 14(8)
Article 10(1 to 3)	Article 16(1) to (3)
Article 10(4)	Article 17
Article 11	Article 20
Article 12	Article 21
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Article 15	Article 28
Article 16	Article 29
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(1) This table indicates the relation between parts of Directive 98/37/EC and the parts of this Directive that deal with the same subject. However, the content of the correlated parts is not necessarily identical.

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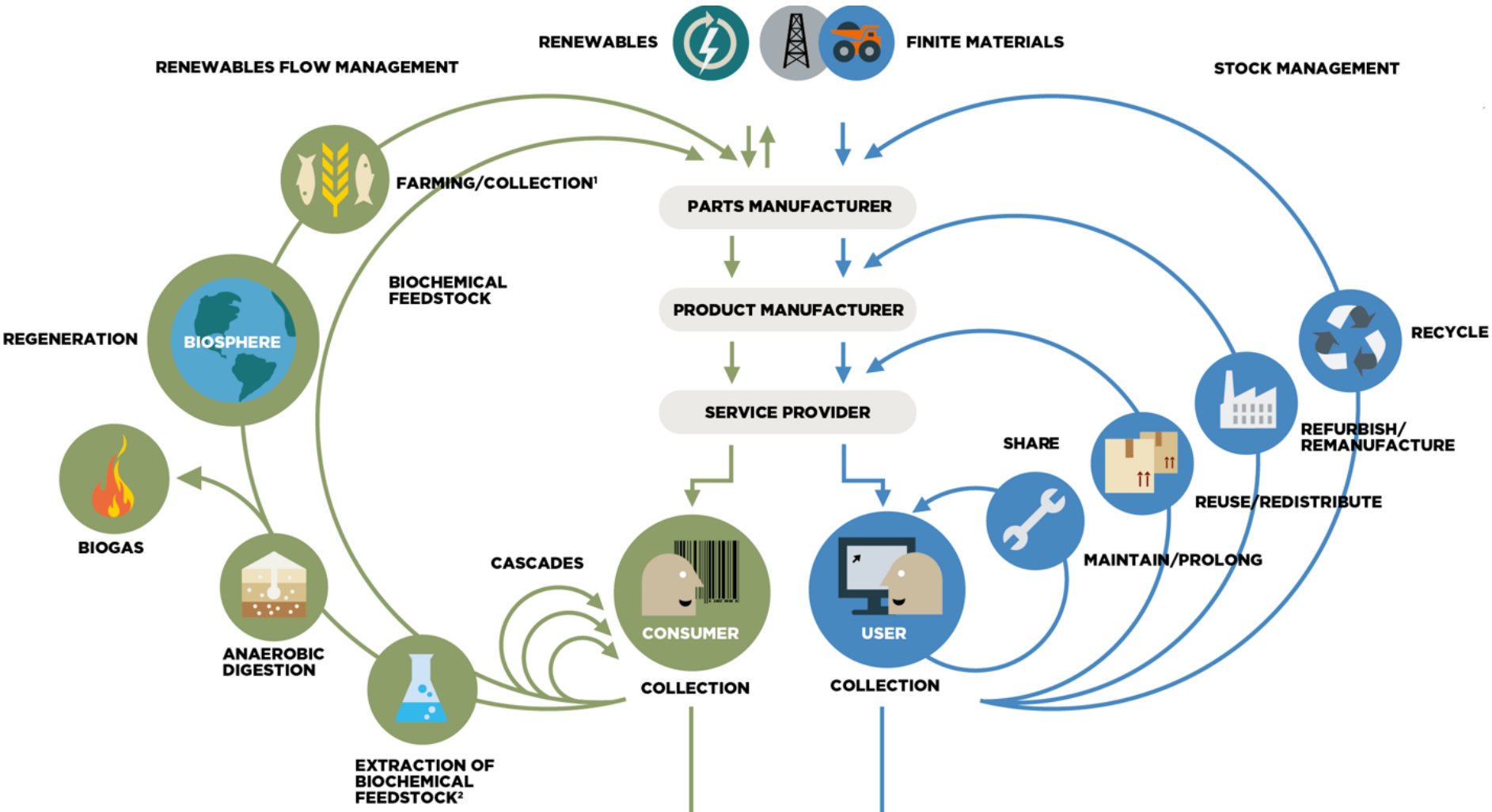
Digital Transformation:

A Made Smarter roadmap for SME manufacturers.

MADE SMARTER

Appendix 13: Ellen MacArthur Foundation –‘ Butterfly’ Diagram



1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input

SOURCE
Ellen MacArthur Foundation
Circular economy systems diagram (February 2019)
www.ellenmacarthurfoundation.org
Drawing based on Braungart & McDonough, Cradle to Cradle (C2C)

ELLEN MACARTHUR FOUNDATION

Smart Protection

- Data Sanitisation
- Data Wiping
- Data Shredding

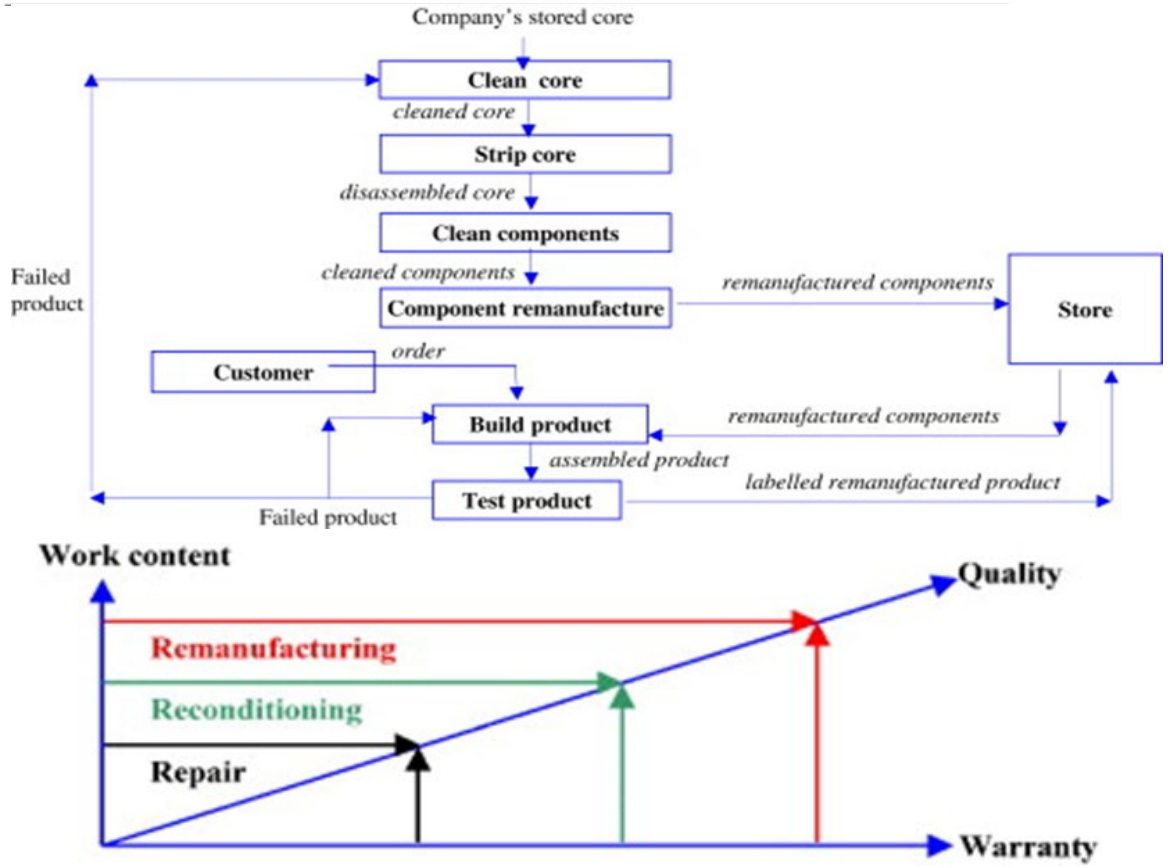
- Reducing Carbon Footprint

Appendix 15

Ijomah, W. L., McMahon, C. A., Hammond, G. P., & Newman, S. T. (2007). Development of design for remanufacturing guidelines to support sustainable manufacturing. *Robotics and Computer-Integrated Manufacturing*, *23*(6), 712–719. https://doi.org/10.1016/j.rcim.2007.02.017

Table 1. Proposed definitions of remanufacturing, reconditioning and repair [19]

Remanufacturing: The process of returning a used product to at least OEM original performance specification from the customers' perspective and giving the resultant product a warranty that is at least equal to that of a newly manufactured equivalent
Reconditioning: The process of returning a used product to a satisfactory working condition that may be inferior to the original specification. Generally, the resultant product has a warranty that is less than that of a newly manufactured equivalent. The warranty applies to all major wearing parts
Repair: Repairing is simply the correction of specified faults in a product. When repaired products have warranties, they are less than those of newly manufactured equivalents. Also, the warranty may not cover the whole product but only the component that has been replaced



Ijomah 2007/2 A model of the operations concerned in remanufacture

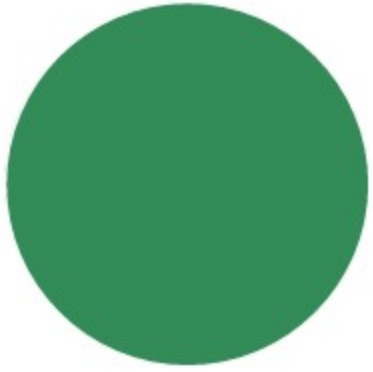
Wooden Packaging Sustainability Report

Pallet Repair | Customer: Knauf, Queensferry

2022

Total no. of pallets

645	Pallet Dust Bag (Mat No. 611066)
5520	2000 x 1200 Repair (Mat No. 685536) 10 Bds
190	1800 x 1200 (6 Bd) Repaired Pallets (2357729)
160	2000 x 600 Repaired Pallet (Mat No. 593619)
1003	2000 x 1200 Repair (Mat No. 2024241) 8 Bds
840	2400 x 1020 Repair (Mat No. 451660)



Total Repaired: **8,358**

Total New: **0**

Savings: **£100k**

Trees Saved: **1,137**

CO_2 Saved: **14 tonnes**

2023

Total no. of pallets

1212	Pallet Dust Bag (Mat No. 611066)
655	1200 x 1200 Repair (2024246)
8255	2000 x 1200 Repair (Mat No. 685536) 10 Bds
40	1800 x 1200 (6 Bd) Repaired Pallets (2357729)
40	1800 x 1200 (Arc) Repaired Pallets
743	2000 x 1200 Repair (Mat No. 2024241) 8 Bds
3136	2400 x 1020 Repair (Mat No. 451660)
1800	2000 x 1200 New Ht (Mat No. 2024241) 8 Bds
17	2300 x 1000 New Pallet

Total Repaired: **14,081**

Total New: **1,817**

Savings: **£138k**

Trees Saved: **2,126**

CO_2 Saved: **26.3 tonnes**

2024 to date

Total no. of pallets

70	Pallet Dust Bag (Mat No. 611066)
93	1800 x 1200 Ref-2357729
580	1200 x 1200 Repair (2024246)
1550	2000 x 1200 Repair (Mat No. 685536) 10 Bds
120	1800 x 1200 (6 Bd) Repaired Pallets (2357729)
328	2000 x 1200 Repair (Mat No. 2024241) 8 Bds
1808	2400 x 1020 Repair (Mat No. 451660)
3570	2000 x 1200 New Ht Pallet (Mat No. 2024241)
600	2400 x 1020 New

Total Repaired: **4,456**

Total New: **4,263**

Savings: **£37.1k**

Trees Saved: **784**

CO_2 Saved: **9.69 tonnes**

2022–2024

TOTAL TREES SAVED: **4,047**

TOTAL CO_2 SAVED: **49.99 tonnes**