Quality management for the processing of medical devices

Qualitätsmanagement für die Aufbereitung von Medizinprodukten

Abstract

Rules on the reprocessing of medical devices were put into place in Germany in 2001. The present article explains the background situation and the provisions that are currently in force. The implementation of these statutory requirements is described using the example of the quality management system of Germany’s market leader, Vanguard AG. This quality management system was successfully certified pursuant to DIN EN ISO 13485:2003 for the scope “reprocessing of medical devices”, including class “critical C”, in accordance with the recommendation of the Commission for Hospital Hygiene and the Prevention of Infection at the Robert-Koch-Institute (RKI) and the German Federal Institute for Drugs and Medical Devices (BfArM) on the “Hygiene requirements for reprocessing of medical devices”.

Keywords: processing of medical devices, processing requirements, processing procedure, quality management, risk management, certification

Zusammenfassung

In Deutschland wurde die Aufbereitung von Medizinprodukten im Jahr 2001 geregelt. In der vorliegenden Arbeit werden die Hintergründe und die bestehenden Regularien erläutert. Am Beispiel des Qualitätsmanagementsystems der Vanguard AG als Marktführer in Deutschland wird die Umsetzung der gesetzlichen Anforderungen beschrieben. Im Ergebnis konnte das Qualitätsmanagementsystem gemäß DIN EN ISO 13485 für den Geltungsbereich der Aufbereitung von Medizinprodukten, einschließlich der Einstufung „kritisch C“, entsprechend der Empfehlung der Kommission für Krankenhaushygiene und Infektionsprävention beim Robert-Koch-Institut (RKI) und des Bundesinstitutes für Arzneimittel und Medizinprodukte (BfArM) zu den „Anforderungen an die Hygiene bei der Aufbereitung von Medizinprodukten“ zertifiziert werden.

Schlüsselwörter: Aufbereitung von Medizinprodukten, Anforderungen an die Aufbereitung von Medizinprodukten, Aufbereitungsverfahren, Qualitätsmanagement, Risikomanagement, Zertifizierung

Regulatory and normative requirements, guidelines and expert recommendations

The fulfilment of the regulatory requirements is a prerequisite for successful quality management. When certifying the quality management system of a company processing medical devices, the certifying body, in addition to official control and supervision, also checks whether these requirements have been fulfilled. The processing of medical devices is also subject to a large number of provisions from various fields. Increasingly in recent years, in addition to safety and hygiene requirements, aspects of environmental management and, most recently, cost-effectiveness and increases in efficiency have come into play. The bibliography contained in this paper does not claim to be complete, as there may also be additional requirements when using special processing techniques or where there are special environmental conditions. The German Ordinance on the Installation, Operation and Use of Medical Devices (MPBetreibV) plays a central role in the configuration, operation and use of medical devices. The ordinance sets out the legal requirements for processing medical devices.

Section 4 MPBetreibV “Maintenance” states:
1. The operator may only commission persons, business or facilities with the requisite specialist knowledge, the requirements and the necessary means to properly carry out this task to perform the maintenance (service, inspection, repair and processing) of medical devices.

2. The processing of medical devices intended to be applied sterile or semi-sterile is to be carried out, while observing the manufacturer’s instructions, using appropriate validated procedures in order to guarantee that the success of these procedures is verifiably ensured, and the safety and health of patients, users or third parties is not put at risk. This also applies to medical devices that are disinfected or sterilised prior to first use. Proper processing pursuant to sentence 1 is assumed if the Joint Recommendation of the Commission for Hospital Hygiene and the Prevention of Infection at the Robert Koch Institute (RKI) and the Federal Institute for Drugs and Medical Devices (BfArM) on hygiene requirements when processing medical devices has been observed.

3. The requirements pursuant to clause 1 are fulfilled where the person commissioned to carry out the maintenance on the basis of his/her training and practical work has the necessary specialist knowledge regarding the maintenance of medical devices, and the premises necessary for this, including the condition, size, fixtures and fitting, as well as the necessary equipment and other working materials, and is in the position to carry out the processing properly and verifiably in the required form and to the required extent.

4. Insofar as these may have been affected by the repair measures, the main structural and functional features essential to the safety and function must be tested following maintenance or repair of medical devices. The persons, businesses or institutions instructed to carry out the tests pursuant to clause 4 must fulfil the requirements pursuant to clause 3 and be independent in their expert judgement when carrying out and evaluating the tests.

This regulation refers with regard to the proper processing of medical devices to the joint RKI and BfArM recommendation. Thus, this recommendation is on a par with an advance expert opinion; it describes the “current technical standard” and is thus de facto a German standard. Special accreditation rules were created with their own sphere of applicability for quality management systems pursuant to EN ISO 13485, in order to ensure evidence of the conformity of medical devices processing with the requirements of the relevant public. Here, the properties of the medical device are assessed (outcome quality), as is the procedure with which the product was produced (process quality).

For the sphere of applicability “processing medical devices classified as ‘critical C’” there are currently four accredited certifying bodies: DEKRA Certification GmbH Stuttgart, LGA InterCert Zertifizierungsgesellschaft mbH, Nuremberg, MEDCERT Zertifizierungs- und Prüfungsgesellschaft für die Medizin GmbH Hamburg and TÜV Rheinland Product Safety GmbH Cologne.

For organisations that provide medical devices, irrespective of the type and size, the quality management norm EN ISO 13485 “Medical devices – quality management systems – requirements for regulatory purposes” applies. This rule describes the requirements regarding the quality of the structure and of the process. Due to safety considerations, this norm was separated from ISO 9001 with the 2003 issue. The main differences are in the fulfilment of customer wishes, the regulatory requirements for medical devices, and the exclusion of provisions of ISO 9001, which are not suitable for medical devices. The requirements with regard to outcome quality are also set forth in technical norms on medical devices, e.g. for intravascular catheters, biocompatibility or specific procedures, such as cleaning, disinfection and sterilisation. With regard to the processing of medical devices, the joint RKI/BfArM recommendation also specifies the requirements for assuring the outcome quality. For example, symbols for labelling medical devices are set out in DIN EN 980. A large number of norms have been developed for the biological assessment of medical devices; more than 50 norms apply to sterilisation, cleaning and disinfection (see also Medical Standards Committee list of norms on processing medical devices). These are by no means exclusively device-related rules. Accordingly, EN ISO 14161 under the heading “Sterilization of health care products – Biological indicators” sets out guidelines on the selection, use and interpretation of results and EN ISO 14971 applies to the risk management requirements for medical devices in the field of steam-sterilisation for sterilised medical goods.

In addition to the regulatory and normative requirements, the guidelines passed by consensus and expert recommendations constitute the current accepted standard of scientific knowledge. Although these are not legally binding, in the event of a breach it must be proven in what other way the necessary care was guaranteed. An example of this is the final report of the RKI Task Force vCJD: Variant Creutzfeld Jakob disease (vCJD) – epidemiology, detection, diagnosis and prevention, taking particular account of minimising risk of iatrogenic transfer through medical devices, particularly surgical instruments.

### Process-oriented quality management systems

By way of an example, this section will show, using the quality management system of Vanguard AG, how a quality management system certified pursuant to EN ISO 13485, which includes the processing of category “critical C” medical devices, can be structured. In accordance with the joint opinion of the German Association for Hospital Hygiene (Deutsche Gesellschaft für Krankenhaustygiene, DGKH) and the Central Authority of the Laender for Health Protection with regard to Medicinal
Products and Medical Devices (Zentralstelle der Länder für Gesundheitsschutz bei Arzneimitteln und Medizinprodukten, ZLG) of August 2006, a certificate pursuant to EN ISO 13485 must explicitly state that the requirements set forth in the joint RKI/BfArM recommendation have been fulfilled if medical device processing with particularly stringent requirements is carried out. Thus, this description also applies to the area of central sterile goods provision (Central Sterilisation Management Department), as, in practice, the classification of medical devices in categories “critical B” and “critical C” is often unclear. While instruments such as laparoscopes, for instance, are sterilised using gas (ethylene-oxide or formaldehyde) instead of with steam on account of the longer useful life, these procedures usually fall within class “critical C”.

The basis of a quality management system (QMS) is the depiction of the business processes on a process map, which is described in the quality management manual (Figure 1).

The processes listed were structured and linked with procedural instructions, taking into account the varying degrees of complexity. In order to keep the description brief but at the same time provide an insight into the depth and the scope of the work entailed in the development and maintenance of a QMS, two management processes have been selected from the process map: the management process “hygiene” and the area of risk management. These will be described below. Furthermore, the following will be presented in more detail: the core process “processing of medical devices with standardised, validated procedures” and the core process “development of validated procedures for medical device processing”.

Management process hygiene

Quality management in the field of hygiene can be structured in different ways. The development of the hygiene plan was carried out on the basis of the rules and regulations issued by the German Federation of Institutions for Statutory Accident Insurance and Prevention (Hauptverband der gewerblichen Berufsgenossenschaften, HVBG) “Biological substances in the healthcare system and in social welfare” (BGR 250/TRBA 250). The integration of the hygiene plan was implemented in the form of a procedural instruction in the quality management documentation. Pursuant to Section 5.1.2 of the Berufsgenossenschaften (BG) rules and regulations it is possible to combine operating instructions and the hygiene plan. This option was selected for reasons of efficiency.

The hygiene regulations were structured as follows: Overview of the premises (description of the premises and allocation of hygiene areas); personnel hygiene (list of workwear and protective clothing); workplace hygiene (furniture, equipment); premises hygiene (list of services for commissioning external service providers); and the cleaning and disinfection plan (measures, responsibilities). The monitoring and testing measures are lodged next to the testing specifications in a hygiene register. In this way, various specifications relating to water used in processing, drinking water cold and warm, indoor air, compressed air and the contamination of work surfaces and personnel can be entered and recorded in the form of a table.

So that the tasks and structures are obvious to each employee, it is advisable to develop pictogrammes, which can be displayed at workstations, on devices and equipment, as well as, if necessary, on the medical devices themselves, or used in the documentation (Figure 2).

The use of pictogrammes increases the employees’ degree of attentiveness and improves orientation. Although graphic elements are used in BGR 250 in Annex 2 using the example of an operating instruction, the rules and regulations themselves do not contain any such requirements. Particularly in the case of persons with a non-German-speaking background or where there is changing personnel in a Central Sterilisation Management Department, it is very important that the visual communication route is also used.

Core process and carrying out of processing medical devices

The processing of medical devices is carried out exclusively using standardised, validated procedures. Since in the case of a “single-use product” responsibility is transferred to the processor, it must be confirmed that patient safety is verifiably not put at risk by the processing and that the function of the processed medical device is not affected.

The core process passes through the following stages: pre-fabrication; processing (cleaning/disinfection) including testing of success of cleaning procedure and function; sterile packaging; sterilisation and final packaging (Figure 3).

Pre-fabrication: In this process stage, incoming control, decontamination, identification and clear labelling of the medical devices are carried out. The partial process stage decontamination incorporates the acceptance of a collection box from the goods entrance and disinfectant pre-cleaning of the medical devices contained therein. Pre-cleaning serves first and foremost personnel protection. Medical devices for which processing can be excluded on the basis of the incoming control (e.g. initial contamination, medical devices incomplete, mechanical damage), are not passed on to the decontamination process, but rather are barred immediately and disposed of as category B waste. The customers are informed as to the medical devices received with the corresponding product status in the form of a confirmation of goods received.

Processing: This process stage encompasses the completion of the preparatory stages defined for processing (e.g. disassembly, assembly, cleaning, disinfection steps) and
**Sterile packaging:** This process stage consists of the visual check, final disinfection, protective packaging by machine, sterile packaging, sealing and checking of the sealed sterile packaging.

**Sterilisation:** Sterilisation encompasses the allocation of the sterile packaged medical devices to a sterilisation process pursuant to the working plan, as well as carrying out the sterilisation in accordance with the required testing and release measures, such as, e.g. batch testing and visual product control.

**Final packaging:** In this stage of the process the medical devices are packed into article-specific external packaging, the labels are produced and affixed. Following a final check, the medical devices are released for distribution. The products are sorted according to customer specifications, packed into in dispatch boxes and handed over to the shipping company.

If individual medical devices are excluded from processing, this is done stating a specified reason for exclusion selected from a catalogue of reasons. However, products are not excluded solely at the pre-fabrication stage, but rather at various points in the process chain. In addition to the purely technical view of the process, the selection of the medical device and the expected success of the processing for a medical device supplied by the customer, i.e. the sustainability of the service model, are worthy of particular attention. The DGKH and the ZLG correctly state in their joint opinion “Ethical, hygienic and legal aspects of the processing of medical devices”, that “the processing, irrespective of whether the medical device is declared for single or repeated use, is even more worthwhile the greater the material and resources needed to manufacture the medical device in question is” and, further, “In the case of disposable medical devices such as e.g. hypodermic syringes, the volume of materials used to manufacture the product is by no means in a reasonablerelationshipto the resources used and hygiene safety in processing, so that this medical device is to be disposed of following a single use”. This clarifies the economic and ecological dimension of processing. However, one must also take into account the aspect of the “willingness” of the customer and, specifically, the physician using the product, to reprocess medical devices.

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(Figures 1 and 2 are diagrams showing the process model for Vanguard AG (Special Processing).)

**Figure 1: Process model for Vanguard AG (Special Processing)**
## Figure 2: Pictogrammes on processing (excerpt)

| Preparation | Disassembly, assembly |
|-------------|-----------------------|
| **Manual cleaning / disinfection** | | |
| Manual cleaning | Chemical wiping disinfection |
| Manual cleaning with the aid of ultrasound | Chemical immersion disinfection |
| Manual enzymatic cleaning | |
| **Machine cleaning / disinfection** | | |
| Machine alkaline cleaning Note: If necessary, the symbol can also be shown with another required pH value, e.g. pH > 10. | |
| Machine neutral cleaning | Machine acidic cleaning |
| Machine enzymatic cleaning | |
| Thermal disinfection Note: if necessary, the symbol can also be shown with another $A_9$-value, e.g. $A_9 < 600$. | Chemothermal disinfection |
| **Sterilisation** | | |
| Steam sterilisation Note: If necessary, the symbol can also be shown with another temperature, e.g. 121°C. | |
| Gas sterilisation with formaldehyde | Plasma sterilisation |
| Gas sterilisation with ethylene oxide / high-pressure procedure | Gas sterilisation with ethylene oxide / vacuum procedure |
| **Warnings** | | |
| Do not immerse! | Do not disassemble! |
| Do not alter temperature! | Do not expose to pressure! |
| No ultrasound! | Do not machine clean! |
The objective of pre-fabrication (incoming control) is to exclude from further processing medical devices that are damaged, incomplete, seriously contaminated or which have not been roughly cleaned in the form agreed with the customer. Yet one and the same medical device e.g. a scraper used in a knee joint arthroscopy can in the course of one use, be used differently from case to case and in particular with varying degrees of intensity. Accordingly, any expectations of a specific quota of processing and thus re-use of the medical devices must be rejected from the outset. It has, however, become apparent that with increasing experience and knowledge of processing technologies on the part of all involved, the degree of processing can be increased - sometimes drastically.

Learning curve

The objective of pre-fabrication (incoming control) is to exclude from further processing medical devices that are damaged, incomplete, seriously contaminated or which have not been roughly cleaned in the form agreed with the customer. Yet one and the same medical device e.g. a scraper used in a knee joint arthroscopy can in the course of one use, be used differently from case to case and in particular with varying degrees of intensity. Accordingly, any expectations of a specific quota of processing and thus re-use of the medical devices must be rejected from the outset. It has, however, become apparent that with increasing experience and knowledge of processing technologies on the part of all involved, the degree of processing can be increased - sometimes drastically.

Figure 3: Processing procedure
Thus, for instance, broken connections in Luer locks can now for the most part be avoided. The successes that can be achieved using the example of the EP diagnostic catheter can be seen clearly in Figure 4. But here also, as is generally known in the quality management field, only a constant drip can hollow stone. Programmes to improve quality, once begun, from time to time need a re-launch. Bonus payments linked with economic success are made transparent for all those involved by providing such evaluations, and the quality of the processing success is experienced first hand. Broad acceptance of economic thinking and actions in medicine is encouraged by a quality management system that is targeted at figures, data, and facts and is, thus, transparent.

**Core process "Development of validated procedures"**

For the development of procedures for processing medical devices, as a central component of Vanguard AG’s special processing a service model was created. It includes: the customer inquiry, an estimate of the need for development, a feasibility study and an estimate of the cost. If the development is approved, the design and development planning procedure follows the same course as for a market authorisation of the medical devices. The special feature of this development process is the product-specific view. If a medical device is sent in and there is already a validated procedure for the group of articles to which the device belongs, the product-specific peculiarities are considered and, accordingly, it is decided which tests are necessary in order to process the medical device. Only following successful completion of all of these tests is the processing of the medical devices approved (Figure 5).

The core process of development of validated procedures was structured as follows:

- preliminary tests
- design and development specifications (design input)
- design output
- transfer to production (design transfer)
- changes to medical devices (change management)
- risk analysis and management

Risk analysis and risk management constitute a cross-divisional function and accompany the entire development process. The information necessary for risk management is derived from all phases of the core process. The risk parameters also serve the direct control of the further procedure in each individual phase. For this reason, the aspects of overriding importance, and the effects thereof on change management are highlighted in the section on risk management, below.

**Preliminary tests:** The main quantitative and qualitative features are identified and the cost-effectiveness is evaluated using manufacturer information, information from literature, norms and experience. The following factors are identified: method of sterilisation, whether
the devices can be rinsed as well as special features in the material and the construction, such as e.g. whether the device can be dismantled. The result of the preliminary tests is the decision on whether, in principle, the devices can be reprocessed.

**Design and development specifications (design input):**
The design and development specifications are defined in detail and a project plan is prepared. The requirements are derived from the corresponding norms and directives. These result in a list of the individual product specifications, such as, for example, permissible length or diameter tolerance, ascertaining the tensile strength, ascertaining electric characteristic values, such as e.g. insulation resistance, line resistance. In this way, the specifications for each individual medical device are drawn up. These specifications are then tested in the course of the valida-
tion and, thereafter, in parallel to the process. At the same time, these specifications represent limit values. If these values are exceeded, the medical device is barred. The specifications are clearly formulated.

The functional parameters are supplemented by requirements in terms of cleanliness, hygiene, sterility and possible sterilisation residue, including endotoxic contamination. These parameters are the same for all medical devices and are set forth in the validation standard “Processing medical devices – general requirements”.

Furthermore, requirements in the individual procedures are defined, e.g. rinsing devices, requirement of special rinsing adapter, and exclusion of certain parameters such as temperature, use of certain chemicals.

A project plan is drawn up which underpins the necessary development work with resources and deadlines. The result of this development phase (“Design Input” phase) are defined requirements for the medical devices (limit values) for the processing procedure, in the form of a target specification or a validation standard, the first stage of a risk management plan and a project plan. The packaging requirements are also specified in this phase.

**Design output:** This is where the actual design activities/verification are carried out, the risk management plan is developed further and the validation is planned and implemented.

These activities also lead to the development of the necessary function-testing devices for the article group. The required packaging materials (e.g. machine protective packaging, protective caps) are defined and a label template is prepared. It is at this stage also that the appropriate machines are selected, together with the parameter set and the agents. This constitutes the actual testing phase.

The risk management plan is supplemented with product-specific specialities. In this way, critical constructional elements, such as the various anti-kink devices for PTCA catheters or various forms of handle for ablation catheters, are determined and their risk potential with regard to the processing is assessed. Furthermore, the critical process stages are determined. This is based on the philosophy that each process stage during the processing (cleaning, disinfection, sterilisation, testing, storage) can affect the medical devices. In order better to be able to assess the risk, tests are included in the validation on the basis of this risk evaluation, which allow the effect of repeated use of the medical devices to be evaluated.

In parallel, in the course of the validation planning a list is drawn up of the tests that are necessary in order verifiably to fulfil the requirements set out in the preceding development phase, and to limit or exclude the ascertained risks. In addition to tests on the hygienic safety, the validation plan includes tests on functional parameters and safety-relevant tests. At this point, the long-term tests that are necessary in order to be able to repeatedly process medical devices are also planned.

**Prerequisites for the selection of medical devices**

A quality management system that sets out and documents all stages is required for the processing. DGKH and ZLG demand that the effectiveness of the procedures be underpinned by product or product-group specific tests, which must be preceded by validation in accordance with the current standard of technology. Any negative effects of the processing on the material properties and the technical-functional safety must be excluded through adequate testing procedures. For disposable products, for which reprocessing is to be considered, the demand for “labelling” arises. In the special processing carried out by Vanguard AG, only medical devices that can be clearly labelled (serial number) by way of laser engraving are included in the preliminary selection. If there is no place e.g. on a handle or an adapter, that can be indelibly marked without causing damage, then processing is prohibited, even if it would otherwise be possible. If we have products from one and the same class with the same function e.g. the arthroscopic scraper of manufacturers A and B, the task is to ascertain which product is suitable for labelling. For decisions regarding repeat orders this is an important contribution made by the special processor for his partner in the healthcare system, the clinical purchasing department. Once the products have been identified, the development of a processing procedure begins. At first glance, it is easy if the manufacturer sells the medical device as re-usable and supplies instructions for use. Here, “instructions for use” is often the more accurate description since this document is sometimes so brief that it cannot actually be referred to as a “processing guideline”. The processor must also exclude incorrect interpretations that can result, for example, from inaccurate translations. The temperature information and the recommended duration of sterilisation usually depend on the technology and chemicals used. Manufacturers very often provide only general information. The following is an excerpt from instructions for use for arthroscopic scrapers designed for a limited number of reuses made by a well-known manufacturer: “After rinsing, immerse all cutting instruments in a cleansing solution with a neutral pH-value, in order to remove or loosen blood, tissue and sebum”. This does not correspond with the state of the art, pursuant to which, for reasons of effectiveness (e.g. to combat TSE virus) alkaline solutions are preferable. Information provided by the manufacturer regarding manual cleaning of their medical devices fails to fully reflect the practical realities. Thus, the following cleaning instruction, which again originates from a renowned manufacturer of arthroscopic scrapers, must be implemented by the processor in a corresponding programme with defined machine cycles and testing criteria: “Do not use scourers or steel wool to clean the instruments. Remove stubborn dirt with a surgical scrubbing brush, by brushing through the internal cutting blade and the outer shell from inside. After soaking and prior to
sterilisation, rinse the instruments under running water for at least three minutes, until the water runs clear". Here, a processor is required to carry out extensive follow-up measures and adjustments in order to bridge these gaps. He must therefore "develop" in order to achieve a procedure that corresponds with the current state of the art – to use the language of the norms, he must ensure "processing according to a controlled and validated process".

At Vanguard, as a result of the risk management process, a special approach was determined for dealing with medical devices that are regularly used in TSE-risk tissue. In addition to two processing stages recommended by the RKI for these purposes (e.g. high-alkaline cleaning), these products are also subject to a protein residue test in parallel to the process. This raised the safety of the processing to a higher level, which was secured further by way of the test. A risk assessment of this kind with the resultant measures should, however, already have been carried out by the manufacturer of a medical device intended to be re-used, since the risk of transfer of TSE virus arises solely on account of the intended use. There is thus no increased risk for products marked as single-use only; on the contrary, the risk of contamination with prions for all medical devices used in TSE-risk tissue must be dealt with.

Once a medical device has attained the status "authorised for processing", Vanguard AG records the stages of the procedure in an IT-based tracking system. If a customised for processing", Vanguard AG records the stages of processing to a higher level, which was secured further in parallel to the process. This raised the safety of the processing to a higher level, which was secured further by way of the test. A risk assessment of this kind with the resultant measures should, however, already have been carried out by the manufacturer of a medical device intended to be re-used, since the risk of transfer of TSE virus arises solely on account of the intended use. There is thus no increased risk for products marked as single-use only; on the contrary, the risk of contamination with prions for all medical devices used in TSE-risk tissue must be dealt with. A risk assessment of this kind with the resultant measures should, however, already have been carried out by the manufacturer of a medical device intended to be re-used, since the risk of transfer of TSE virus arises solely on account of the intended use. There is thus no increased risk for products marked as single-use only; on the contrary, the risk of contamination with prions for all medical devices used in TSE-risk tissue must be dealt with.

Once a medical device has attained the status “authorised for processing”, Vanguard AG records the stages of the procedure in an IT-based tracking system. If a customer provides a medical device for processing, the medical devices supplied are directed into one of two core processes; in the case of first processing this occurs after the products have been identified by way of laser engraving (Figure 6).

The medical devices with the status “authorised for processing” represent the entire spectrum of processable products. The medical devices with the status “in development” reflect potential future activities. The classification “not processable” means that, according to the evaluation, no processing procedure is available for the medical device.

The cleaning effectiveness is directly linked to the geometry and type of contamination of the specific medical devices. The following two situations may arise:

• There is no suitable facility, no suitable rinsing adapter or no cleaning procedure (cleaning products and disinfectants, temperature, number of cleaning and rinse cycles). With the development of facilities, rinsing adapters or procedures, first of all, tests are carried out to determine whether all component parts of the medical devices can be sufficiently rinsed. To begin with, coloured soiling agent is used. Only after the parameters have been successfully ascertained (pressure, temperature, number of cycles etc.), is test soiling carried out. The cleaning effectiveness is assessed visually, by ascertaining residue containing protein (OPA), by ascertaining microbial contamination (bioburden test) after cleaning and by determining bacterial endotoxins after cleaning and sterilisation. If necessary, tests for residue tensides or degradation products of the substances used are also carried out. Spectroscopic or titrimetric methods are used here. Only once the cleaning effectiveness is successful in all points can the procedure be approved for processing.

• If a new medical device can be processed in an existing facility with known rinsing adapters and known procedures (cleaning and disinfectant agent, temperature range, etc.), the cleaning effectiveness is measured by cleaning a representative selection of applied medical devices using the existing procedures. Here, too, the procedure is approved only once all aspects of the process have been verified as safe.

The result of the “Design Output” phase is suitable testing apparatus, allocated packaging and identification means, designated machinery and parameter rates, the second step of a risk management plan and a validation plan. Transfer to production (design transfer): During the concluding Design Transfer Phase in the course of the implementation of production the developed testing apparatus and any necessary raw materials are handed over and the production staff is provided with training on how to operate the machinery and the testing apparatus. A study protocol is developed which sets out what product-specific tests have to be carried out in parallel to the production, for which medical devices, and with which specifications to what extent and at which control point. Since many tests are damaging, the procedures are developed so that a parametric assessment can be made. In this way, using the evaluation of the recorded machine parameters, the processed batch can be released. In addition, the use of test blocks and the examination of process media are planned. The study protocol is integrated into the working plan. The design transfer concludes the validation. Using the results from the validation tests, all requirements for the medical device and the procedure are confirmed and it is determined for each medical device, how often, in theory, it can be processed. New products are also used for the validation. The result of this phase is a validated procedure for defined medical devices in a product group. This is expressed in an approved working-plan sheet, which makes reference to the necessary documents (manufacturing and testing instructions, operating instructions, etc.)
Risk analysis and risk management

As explained in the context of the development of validated procedures, the process of developing procedures and product release is accompanied by risk management, taking into account the special features of the re-use of the medical device. On the basis of the classification pursuant to the “hygiene requirements when processing medical devices”, the hygiene risks that result from contamination when used as instructed are assessed. Already at the preliminary planning stage, (Design-Input) mechanical strain during use, the effect of storage/transport, the strain on the medical devices caused by the individual processing stages, including the necessary tests for the article group, are monitored. The procedure follows EN ISO 14971, which concerns the application of risk management to medical devices. The norm assumes that, when using a medical device, a risk has two components. These are, firstly, the likelihood of the occurrence of damage and secondly, the results or the severity of this damage. The norm is addressed primarily to the manufacturers of medical devices, but also identifies physicians, patients, the government and the public as involved parties. The norm also sees itself as an intermediary: “All those involved must understand that the use of a medical device involves a certain degree of risk” and further “the perception of the risk on the part of those involved can vary greatly, depending on the type, including cultural background, the socio-economic background and the level of education of the relevant society, of the actual and perceived health of the patient and many other factors”. The norm applies for the entire lifecycle of a medical device. Thus, the risk management process encompasses not only the risk assessment prior to placing on the market, but also risk monitoring on completion of the product. The documentation is carried out in the form of a risk management file (Table 1). This file serves to prove the “completeness of the risk management”. This includes the evaluation of existing and recognised risks, the development of measures to minimise risks and the re-evaluation thereof, in order, in this way, to verify the management of the remaining risks. The norm does not, however, set out any acceptable levels of risk. This remains the decision of the manufacturer or the groups involved. Nevertheless, Annex D to the norm (risk concepts) contains suggestions for qualitative and quantitative analyses. In practice, this results in a risk chart, in which an acceptance parameter is formed from the risk potential, the identifiability and the likelihood of occurrence. The specific use will now be clarified using the example of a risk analysis for an arthroscopic scraper (Table 2). Two functions of the analysis were selected: “the removal of tissue (cutting) – subpoint 2.3, “unclean removal” and, as a contribution to the issue of reprocessing, “processing – subpoint 7.4. “introduction of foreign material or processing means to the organism”.”

In both cases, it is possible using appropriate measures to reduce the risk from level 9 (unacceptable) to risk level 6 (“as low as reasonably practicable”; ALARP). In the course of the further development of the norm ISO 14971:2005, the risk classes were consolidated into just two groups – acceptable risk and unacceptable risk. The manufacturer and the user are, however, free to employ individual risk management techniques. Accordingly, Annex G to the norm lists the following techniques as suitable and useful:

- Preliminary Hazard Analysis (PHA) – a technique that can be used at an early stage of the development of a medical device.
- Fault Tree Analysis (FTA) – helpful when interpreting safety technology and determining ranking of hazards.
- Failure Mode and Effect Analysis (FMEA) – to support risk assessments and risk measures once the medical devices is completed.
- Hazard and Operability Studies (HAZOP) and the hazard analyses and critical control points (HACCP) are recommended for the verification and optimisation of structure designs. HAZOP is similar to FMEA. HACCP was developed by NASA in order to prevent food poisoning among astronauts. In the area of medical devices it helps in the cause analysis for hazards.

Thus, there are a series of accepted methods for managing risk. The structure of the risk management file should reflect the fact that risk management is continuously developing further.

Particular aspects of special processing

When processing medical devices released by the manufacturer for single use, an essential aspect of the risk considerations is recognising critical areas, which, in the event of modifications, can affect functional or hygiene properties of the product, such as e.g. anti-kink variants, shape of handles. As modifications can also affect the labelling, medical devices should only be processed if the customer at least provides the manufacturers’ labels for each individual medical device. Since the release for processing must relate to a specific article, any change to the manufacturer’s reference (catalogue number) is immediately apparent and has to be reprocessed by the development department. Changes to the contents or the design of the label will also be obvious to trained finishing staff. In such cases the relevant responsible person is to be informed, and will then decide on how to proceed. Changes or modifications are occasionally made by the manufacturer under the same reference number. A typical example of a modification is alterations to join connections, which can be mechanical (screw, snap-in) or chemical (glue, welding). For this reason, tests to accompany the production stage are derived from the risk analysis.

Possible changes to the materials that are not stated in the manufacturer’s documentation are highly unlikely,
Table 1: Example of a risk chart

| Severity of harm | Probability of occurrence of Harm |  |
|------------------|-----------------------------------|---|
| Identification   | improbable | remote | occasional | probable | frequent |
| catastrophic     | 6          | 7       | 8          | 9        | 10       |
| critical         | 4          | 6       | 7          | 8        | 9        |
| critical         | difficult  | 4       | 5          | 6        | 7        | 8        |
| critical         | Easy       | 3       | 5          | 6        | 6        | 8        |
| marginal         | No         | 3       | 4          | 5        | 6        | 7        |
| marginal         | difficult  | 2       | 3          | 4        | 5        | 6        |
| marginal         | easy       | 1       | 2          | 3        | 4        | 5        |
| marginal         | 0          | 1       | 2          | 3        | 4        |

Acceptable (0-3)

The severity of the harm of a mistake is so low that the risk is negligible in comparison to the benefit. For this hazard there does not necessarily have to be a risk reduction. **ALARP (as low as reasonably practicable) 4-6**

Area between acceptable and unacceptable risks.

Risks in this area must be carefully evaluated with regard to the beneficial effect of the product and the effort involved in risk reduction. Each risk must be reduced to a level that is “as low as reasonably practicable”.

Unacceptable (>6)

Risks in this area are so serious that a system entailing such hazards would be untenable. Risks in this area must be reduced by limiting the severity of the harm and/or the likelihood of occurrence.

Table 2: Risk analysis for an arthroscopic scraper (excerpts)

| Function                           | Risk analysis | Risk assessment |
|------------------------------------|---------------|-----------------|
|                                    | risk analysis | Risk assessment |
|                                    | hazards       | Assessment prior to risk reduction |
| Removal of tissue parts (cutting)  | 2.3 No        | Removal of tissue parts (cutting) 2.3 No |
|                                    | Removal       | Damage          |
|                                    | of           | Cause           |
|                                    | tissue parts | Occurrence       |
|                                    | (cutting)     | Identifiability |
|                                    | Altered       | Potential       |
|                                    | cutting-     | hazard          |
|                                    | geometry or   | acceptance       |
|                                    | damage to    |                 |
|                                    | blade(s)     |                 |
|                                    | (scratches,  |                 |
|                                    | nicks, blunt |                 |
|                                    | instrument)  |                 |
|                                    | probable      |                 |
|                                    | serious       |                 |
|                                    | catastroph ic |                 |
| Other                              | 7.4           | Other           |
|                                    | Introduction  | Damage          |
|                                    | of foreign    | Cause           |
|                                    | material      | Occurrence       |
|                                    | and/or        | Identifiability |
|                                    | processing    | Potential       |
|                                    | solution(s)   | hazard          |
|                                    | into the      | acceptance       |
|                                    | organism      |                 |
|                                    | -Inflammation |                 |
|                                    | -Toxic       |                 |
|                                    | reaction      |                 |
|                                    | -Infection    |                 |
|                                    | blockage in   |                 |
|                                    | the shaft     |                 |
|                                    | parts due to  |                 |
|                                    | insufficient  |                 |
|                                    | cleaning      |                 |
|                                    | effectiveness |                 |
|                                    | probable      |                 |
|                                    | serious       |                 |
|                                    | catastroph ic |                 |
|                                    | 9             |                 |

Risk reduction

| Function                           | Measures |
|------------------------------------|----------|
|                                    | Evaluation following risk reduction |
|                                    | occurrence | Identifiability | Potential | hazard | Acceptance | Other hazards | created | All hazards | recorded |
| Removal of tissue parts (cutting)  | 2.3 No    | Removal of tissue parts (cutting) 2.3 No |
|                                    | -Ensuring | Measures         |
|                                    | unaltered | Measures         |
|                                    | blade     | Measures         |
|                                    | geometry  | Measures         |
|                                    | in        | Measures         |
|                                    | comparison | Measures         |
|                                    | with new  | Measures         |
|                                    | product   | Measures         |
|                                    | -use of  | Measures         |
|                                    | defined   | Measures         |
|                                    | working   | Measures         |
|                                    | plans     | Measures         |
|                                    | -Checking | Measures         |
|                                    | cutting   | Measures         |
|                                    | geometry  | Measures         |
|                                    | (100%     | Measures         |
|                                    | Functional | Measures         |
|                                    | test      | Measures         |
|                                    | -If      | Measures         |
|                                    | necessary, | Measures         |
|                                    | restoring | Measures         |
|                                    | blade     | Measures         |
|                                    | geometry  | Measures         |
|                                    | -Implementation | Measures         |
|                                    | of processing | Measures         |
|                                    | by qualified | Measures         |
|                                    | staff     | Measures         |
|                                    | improbable | Measures         |
|                                    | simple    | Measures         |
|                                    | catastroph ic | Measures         |
|                                    | 6         | Measures         |
|                                    | *         | Measures         |
|                                    | yes       | Measures         |
| Miscellaneous                      | 7.4 No    | Miscellaneous 7.4 No |
|                                    | -100%      | Measures         |
|                                    | check of | Measures         |
|                                    | cleaning  | Measures         |
|                                    | effectiveness | Measures         |
|                                    | (consistency | Measures         |
|                                    | use of a  | Measures         |
|                                    | validated  | Measures         |
|                                    | processing | Measures         |
|                                    | procedure | Measures         |
|                                    | -Defined  | Measures         |
|                                    | working   | Measures         |
|                                    | plan      | Measures         |
|                                    | improbable | Measures         |
|                                    | simple    | Measures         |
|                                    | catastroph ic | Measures         |
|                                    | 6         | Measures         |
|                                    | no        | Measures         |
|                                    | yes       | Measures         |

* if necessary, surface changes due to the reconstruction of the blade geometry
since the high level of regulatory effort (notification of changes, if necessary biocompatibility certificates, proof of function) is used as a marketing instrument of “technical innovation”. For medical devices with a relatively short life-span, such as PTCA catheters, changes of this kind (e.g. change in colour) account for a large proportion of competition. This is why revalidations are planned and carried out for instruments with a long useful life. Recognised modifications or high error rates lead to a modification in the risk assessment and changes to the test frequency and level of the tests. For this reason, in practice, it is not uncommon for a medical device to be unsuitable for reprocessing following modification.

Changes to medical devices (Change management)

When developing validated procedures for processing medical devices it is particularly important that modifications by the manufacturer are taken into account throughout the entire life-cycle of the medical device. Under the provisions of the Medical Device Act, alterations to medical devices by the manufacturer are subject to a documentation obligation and, depending on the classification of the medical device, have to be notified to the designated authorising body. There is not, however, an obligation to notify changes to the user and/or processor. This relates to both single-use products and medical devices declared to be for repeated use. Consequently, to ensure patient safety within the framework of quality management, a change management system must be installed in the functional areas of development, production and distribution. It includes risk analyses, release decisions (validation), continual monitoring in the form of tests accompanying the process, market observation and revalidation. Regular product-specific training and a close communicative connection between the individual areas of operation are additional cornerstones of change management. The use of process software and the individual labelling of each individual product ensures that it is possible at all times to react to alterations to medical devices by barring them from processing or, if necessary, carrying out a targeted product recall. These instruments can also be used to react to product recall measures by the manufacturers of medical devices.

The development of risk management systems and the partial components thereof, such as Change Management, is a necessity arising both from ISO 14971 and the Medical Devices Operator Ordinance, which has already been presented in detail. Section 4 MPBetreibV sets forth the legal requirements when processing medical devices. Qualified staff, expert knowledge and technical facilities suitable to meet the requirements form the basis of an effective risk management system. A quality management system pursuant to EN ISO 13485 forms the keystone for the sustainable, cost-effective and efficient provision of services in the sterile goods supply sector.

References

Acts, Ordinances and Directives

- German Act on Medical Devices (Medizinproduktegesetz, MPG)
- German Product Liability Act (Produkthaftungsgesetz, ProdHaftG)
- German Act on the Prevention of Infection (Infektionsschutzgesetz, IfSG)
- Council Directive 93/42/EEC Concerning Medical Devices
- German Ordinance on Industrial Safety and Health (Betriebssicherheitsverordnung, BetrSichV)
- German Medical Device Operator Ordinance (Medizinprodukte-Betreiberverordnung, MBetreibV)
- Medical Devices Ordinance (Medizinprodukte-Verordnung, MPV)
- Ordinance on the recording, evaluation and prevention of risks relating to medical devices (Safety Plan for Medical Devices - Medizinprodukt-Sicherheitsplanverordnung, MPSV)
- Hygiene requirements when processing medical devices, Joint Recommendation of the Commission for Hospital Hygiene and the Prevention of Infection at the Robert Koch-Institute and the Federal Institute for Drugs and Medical Devices. BGBl 200;1s44:1115-26.
- The variants of Creutzfeldt-Jakob disease (vCJD) - Epidemiology, diagnosis and prevention taking particular account of minimising the risk of iatrogenic transfer through medical devices, specifically surgical instruments - Final Report of the Task Force on vCJD. BGBl 2002;45:376-94.
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Norms and references to norms

- EN ISO 10993-1: Biological evaluation of medical devices - Part 1: Evaluation and testing within a risk management system
- EN ISO 10993-2: Biological evaluation of medical devices - Part 2: Animal welfare requirements
- EN ISO 10993-3: Biological evaluation of medical devices - Part 3: Tests for genotoxicity, carcinogenicity and reproductive toxicity
- EN ISO 10993-4: Biological evaluation of medical devices - Part 4: Selection of tests for interactions with blood
- EN ISO 10993-5: Biological evaluation of medical devices - Part 5: Tests for cytotoxicity: in vitro-methods
- EN ISO 10993-7: Biological evaluation of medical devices - Part 7: Ethylene oxide sterilization residuals
- EN ISO 10993-8: Selection and qualification of reference materials for biological tests
• EN ISO 10993-9: Biological evaluation of medical devices - Part 9: Framework for identification and quantification of potential degradation products
• EN ISO 10993-10: Biological evaluation of medical devices - Part 10: Tests for irritation and delayed-type hypersensitivity
• EN ISO 10993-11: Biological evaluation of medical devices - Part 11: Tests for systemic toxicity
• EN ISO 10993-12: Biological evaluation of medical devices - Part 12: Sample preparation and reference materials
• EN ISO 10993-13: Biological evaluation of medical devices - Part 13: Identification and quantification of degradation products from polymeric medical devices
• EN ISO 10993-14: Biological evaluation of medical devices - Part 14: Identification and quantification of degradation products from ceramics
• EN ISO 10993-15: Biological evaluation of medical devices - Part 15: Identification and quantification of degradation products from metals and alloys
• EN ISO 10993-16: Biological evaluation of medical devices - Part 16: Toxicokinetic study design for degradation products and leachables
• EN ISO 10993-17: Biological evaluation of medical devices - Part 17: Establishment of allowable limits for leachable substances
• EN ISO 10993-18: Biological evaluation of medical devices - Part 18: Chemical characterization of materials
• EN ISO 13485: Medical Devices. Quality Management Systems. Requirements for Regulatory Purposes
• EN ISO 14161: Sterilization of health care products - Biological indicators - Guidance for the selection, use and interpretation of results
• EN ISO 14937: Sterilization of health care products - General criteria for characterization of a sterilizing agent and the development, validation and routine control of a sterilization process for medical devices
• EN ISO 14971: Medical Devices - application of risk management to medical devices
• EN ISO 15882: Sterilization of health care products - Chemical indicators - Guidance for selection, use and interpretation of results
• EN ISO 15883-1: Washer-disinfectors - Part 1: General requirements, terms and definitions and tests
• EN ISO 15883-2: Washer-disinfectors - Part 2: Requirements and tests for washer-disinfectors employing thermal disinfection for surgical instruments, anaesthetic equipment, bowls, dishes, receivers, utensils, glassware, etc.
• EN ISO 15883-4: Washer-disinfectors - Part 4: Requirements and tests for washer-disinfectors employing chemical disinfection for thermo-labile endoscopes
• EN ISO 17664: Sterilization of medical devices - Information to be provided by the manufacturer for the processing of resterilizable medical devices
• DIN 58946-1: Sterilization; steam sterilizers for medical products; terminology
• DIN 58946-6: Sterilization; steam sterilizers - part 6: Operation of large-scale sterilizers in the healthcare system
• DIN 58946-7: Sterilization - Steam sterilizers - Part 7: Requirements on installation and services
• DIN 58947-1: Sterilization; hot air sterilizers; terminology
• DIN 58947-3: Sterilization; hot air sterilizers; efficiency testing
• DIN 58947-5: Sterilization; hot air sterilizers; small sterilizers, requirements
• DIN 58947-6: Sterilization; hot air sterilizers; operation of hot air sterilizers
• DIN 58948-16: Sterilization - Low temperature sterilizers - Part 16: Operation of low temperature steam formaldehyde sterilizers
• DIN 58948-17: Sterilization - Low temperature sterilizers - Part 17: Requirements for the installation and operation of low temperature steam formaldehyde and formaldehyde sterilizers and their supply sources
• DIN 58948-6: Sterilization; gas sterilizers; operating of ethylene oxide gas sterilizers
• DIN 58948-7: Sterilization - Low temperature sterilizers - Part 7: Requirements on the installation and requirements on the service supply for ethylene oxide sterilizers
• DIN 58949: Disinfection - Steam disinfection-apparatus
• DIN 58952-2: Sterilization; packing materials for sterilizing goods, sterilizing baskets made of metal
• DIN 58952-3: Sterilization; packing materials for sterilizing goods, instrument trays made of metal
• DIN 58953-1: Sterilization; sterile supply; terminology
• DIN 58953-10: Sterilization; sterile supply; handling of plain and creped sterilization paper
• DIN 58953-6: Sterilization - Sterile supply - Part 6: Microbial barrier testing of packaging materials for medical devices which are to be sterilized
• DIN 58953-7: Sterilization - Sterile supply - Part 7: Use of sterilization paper, nonwoven wrapping material, textile materials, paper bags and sealable pouches and reels
• DIN 58953-8: Sterilization - Sterile supply - Part 8: Logistics of sterile medical devices
• DIN 58953-8: Sterilization; sterile supply; delivering of sterile medical devices for single use as well as its storage and handling
• DIN 58953-9: Sterilization; sterile supply; Handling of sterilizing container
• EN 13060: Small steam-sterilizers
• EN 14180: Sterilizers for medical purposes - Low temperature steam and formaldehyde sterilizers - Requirements and test methods
• EN 1422: Sterilizers for medical purposes - Ethylene oxide sterilizers - Requirements and test methods
• EN 285: Sterilization, steam sterilizers, large sterilizers
• EN 550: Sterilization of medical devices - Validation and routine control of ethylene oxide sterilization
• EN 554: Sterilization of medical devices - Validation and routine control of sterilization by moist heat
EN 556-1: Sterilization of medical devices - Requirements for medical devices to be designated "STERILE" - Part 1: Requirements for terminally sterilized medical devices
EN 866: Biological systems for testing sterilizers and sterilization processes
EN 867: Non-biological systems for sterilizers
EN 868-1: Packaging materials and systems for medical devices which are to be sterilized. General requirements and test methods
EN 868-10: Packaging materials for terminally sterilized medical devices - Part 10: Adhesive coated non-woven materials of polyolefines for use in the manufacture of sealable pouches, reels and lids - Requirements and test methods
EN 868-2: Packaging for terminally sterilized medical devices - Part 2: Sterilization wrap - Requirements and test methods;
EN 868-3: Packaging for terminally sterilized medical devices - Part 3: Paper for use in the manufacture of paper bags (specified in EN 868-4) and in the manufacture of pouches and reels (specified in EN 868-5) - Requirements and test methods;
EN 868-4: Sterilization - Sterile supply - Part 7: Use of sterilization paper, nonwoven wrapping material, textile materials, paper bags and sealable pouches and reels
EN 868-5: Packaging materials for terminally sterilized medical devices - Part 5: Sealable pouches and reels of porous materials and plastic film construction - Requirements and test methods
EN 868-6: Packaging materials for terminally sterilized medical devices - Part 6: Paper for the manufacture of sterile barrier systems intended for sterilization by low temperature sterilization processes or irradiation - Requirements and test methods
EN 868-7: Packaging materials and systems for medical devices which are to be sterilized - Part 7: Adhesive coated paper for the manufacture of heat sealable packs for medical use for sterilization by ethylene oxide or irradiation - Requirements and test methods
EN 868-8: Packaging materials for terminally sterilized medical devices - Part 8: Re-usable sterilization containers for steam-sterilization conforming to EN 285; requirements and test methods
EN 868-9: Packaging materials for terminally sterilized medical devices - Part 9: Uncoated nonwoven materials of polyolefines for use in the manufacture of sealable pouches, reels and lids - Requirements and test methods
EN 980: Symbols for use in the labelling of medical devices

Editorial note
This contribution was written for the present issue at the editor’s request, because it rounds off the subject matter perfectly. It provides a synopsis of the following articles:

Klosz K. Wiederverwendung von Medizinprodukten. In: von Eiff W, editor. Schriftenreihe Gesundheitswirtschaft. Vol. 2: Risikomanagement: Kosten-/Nutzen-basierte Entscheidungen im Krankenhaus, 2nd ed. Wegscheid: Wikom; 2007. p. 499-531.
Kramer A, Popp W, Heudorf U, Klosz K, Assadian O, Dietlein E, et al. Qualitätsmanagement der Hygiene in ausgewählten industriellen, medizinischen und sozialen Bereichen. In: Kramer A, Assadian O, editors. Wallhäußers Praxis der Sterilisation, Desinfektion, Antiseptik und Konservierung. Qualitätssicherung der Hygiene in medizinischen und industriellen Bereichen. Stuttgart: Thieme; 2008. p. 413-26.
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