

Issues and Experiences on Radioactive Waste Quality Control / Quality Assurance with Regard to Future Disposal

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ABSTRACT

In the Federal Republic of Germany all types of radioactive waste (short-lived, long-lived) are to be disposed of in deep geological formations. Thus, the safe management of radioactive waste presupposes an appropriate conditioning of primary waste-to-waste packages suitable for emplacement in a repository as well as the documentation of pre-treatment, processing and packaging steps and the waste package characteristics being relevant for disposal.

Due to the operation, decommissioning and dismantling of nuclear facilities as well as the application of radioisotopes in industry, medicine and research & development radioactive waste continuously arises in Germany. In order to manage this waste different measures and procedures regarding its conditioning and quality control/quality assurance were introduced and since many years successfully applied. Waste conditioning is especially characterized by a flexible application of the Konrad waste acceptance requirements. The rationale for this approach is due to the present non-availability of a repository in Germany. Several examples of a “tailor-made” application of the waste acceptance requirements in treatment, conditioning and documentation processes as well as the quality assurance/quality control processes illustrate the current German approach.

THE FEDERAL OFFICE FOR RADIATION PROTECTION

The Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) is a federal authority in the portfolio of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU).

Pursuant to § 23 Atomic Energy Act [1] BfS is legally responsible for the construction and operation (including closure) of federal facilities for the disposal of radioactive waste. As a quality target, BfS must take care that compliance in particular with the protection goals of the Atomic Energy Act [1] and the Ordinance on Radiation Protection [2] is systematically ensured. Within the scope of this responsibility, waste package quality assurance/quality control is also incumbent upon BfS.

THE STRUCTURE OF THE BFS QM SYSTEM

In the BfS quality management manual (QM manual) compliance with the requirements set out in the standards is defined. It is primarily a guide to the BfS provisions and instructions and shows how the requirements set out in the standards are implemented. The documentation structure is shown in Fig. 1.

The top level in the hierarchy of documents in an authority consists of its terms of procedure (Geschäftsordnung, GO) regulating the general routine and the general business as well as the organization chart and the schedule of responsibilities.

The second level is represented by procedures (Dienstanweisungen, DA). The procedures describe the WHO?, WHAT?, WHEN? and HOW?. Procedures are effective in all organizational units of BfS and are issued by the Senior Management.

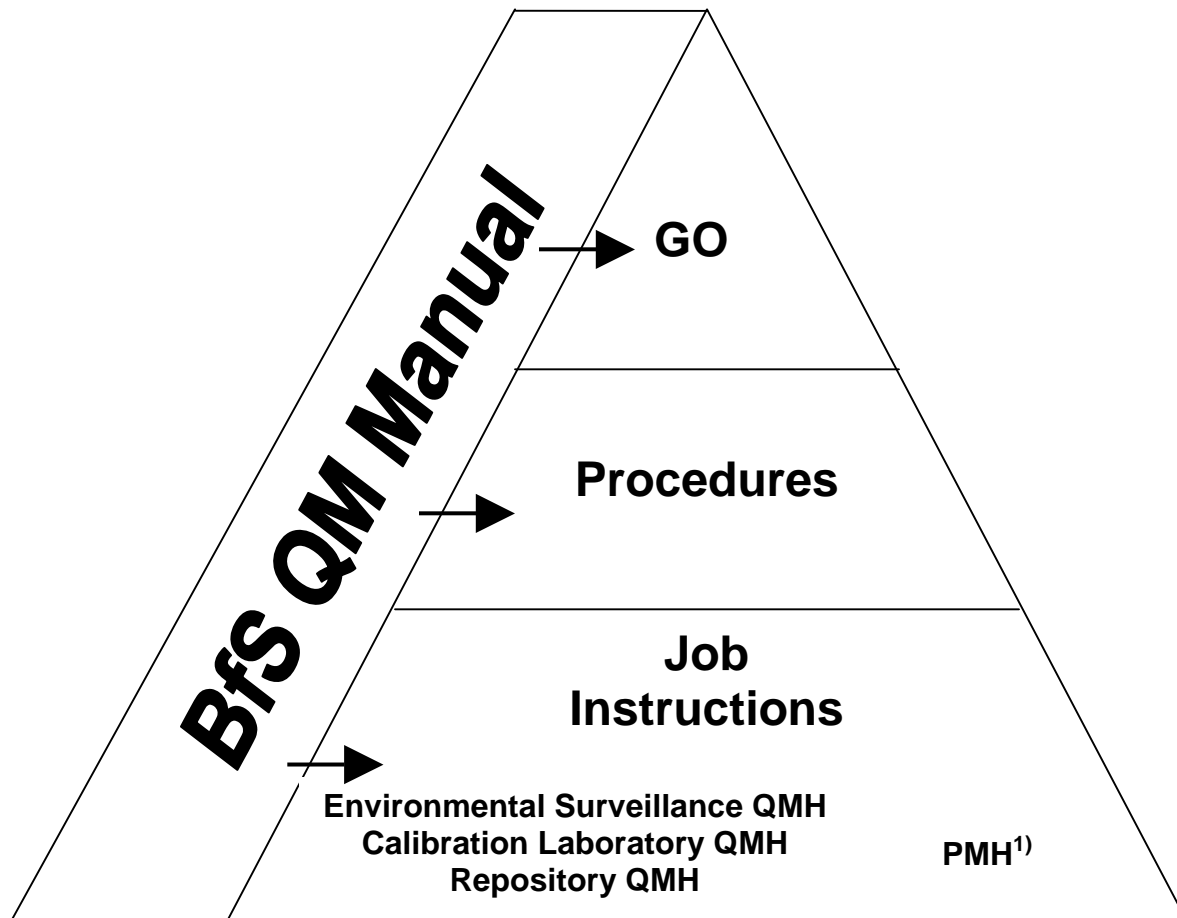


Fig. 1. Documentation structure

¹⁾ e. g., process management manual relating to waste package quality assurance/quality control

On the third level, all other job instructions (Arbeitsanweisungen, AA) are summarized, such as the calibration laboratory QM manual, the repository QM manual, the process management manual relating to waste package quality control, the environmental monitoring QM manual or the process management manual relating to waste package quality control (PMH). The job instructions also describe the WHO?, WHAT?, WHEN? and HOW?. Job instructions usually apply to one department and/or its organizational units and are basically implemented by the respective department head.

The first BfS quality assurance system was introduced for the disposal of radioactive waste.

Responsibility for the QM system is with the Senior Management. The operative tasks concerning the introduction and maintenance of the necessary processes according to the provisions of the QM system are executed by the organizational unit of Quality Assurance Monitoring (Qualitätssicherungsüberwa) (Qualitäts-beauftragte, QB) are organizationally integrated. The quality assurance officers are supervised by QSÜ. Disciplinary seniors are the respective heads of the organizational units.

The QM manuals of the accredited calibration laboratories and the QM manual of the organizational units in charge of disposal-related work and the PM manuals such as the process management manual on waste package quality control are integrated in the QM system. The QM documentation is updated by QSÜ.

TASK SPECIFIC QUALITY MANAGEMENT SYSTEMS

As already mentioned, BfS is responsible for the construction and operation (including closure) of a repository for radioactive waste. To be able to prove that the necessary measures against discrepancies have been taken during the planning phase and have remained unchanged during construction and operation (including closure), BfS introduced task specific quality management systems for waste package quality control and for the responsible organizational units (Organisationseinheiten, OE). These task specific quality management systems ensure compliance with quality demands.

The repository quality management system comprises the quality assurance of all measures within the scope of the site exploration, construction and operation (including closure) of a repository. It ensures that the necessary preventive measures against incidents have been included in the planning phase and remain unchanged during construction and operation. To guarantee this, process instructions have been developed in which the corresponding processes are described.

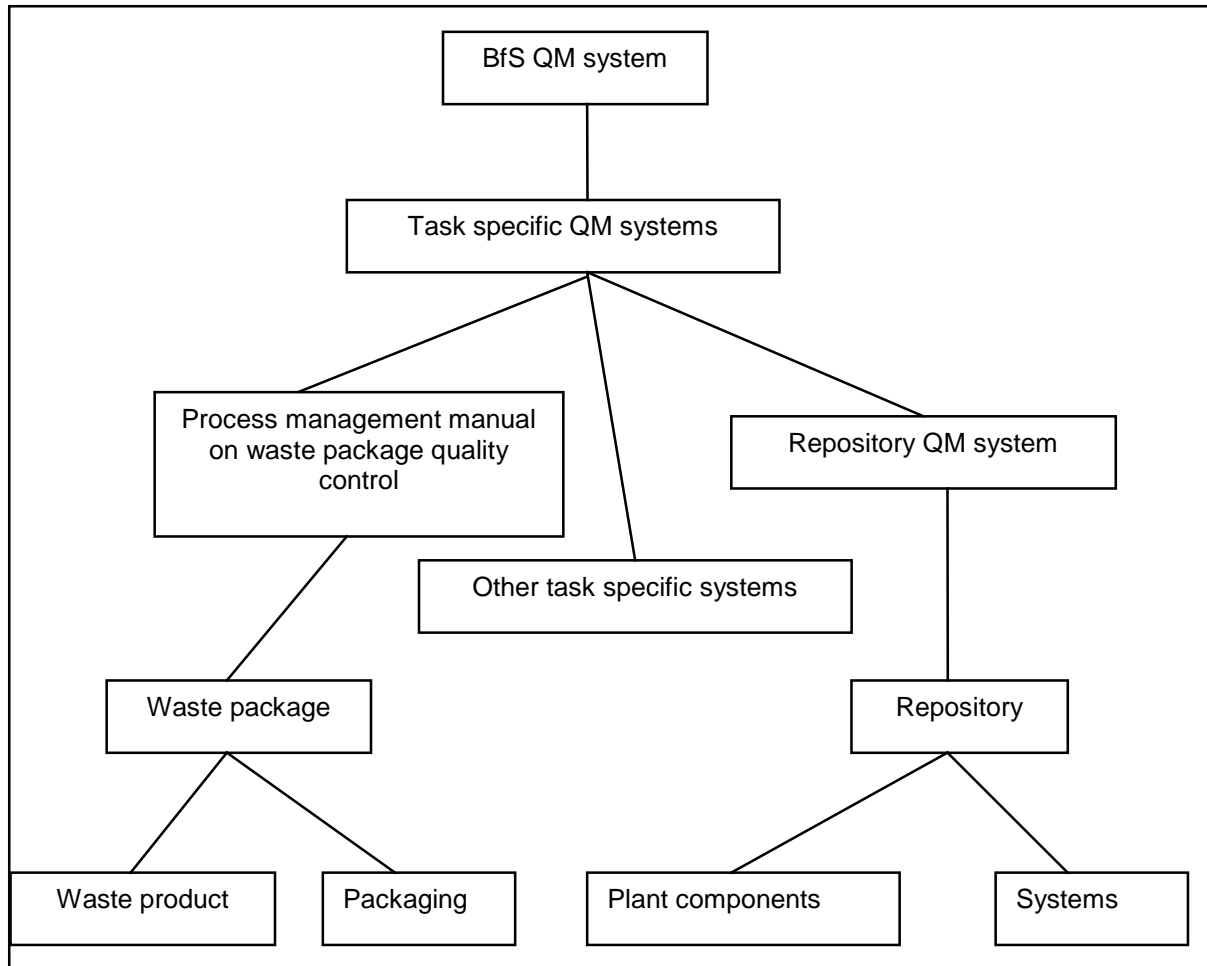


Fig. 2. BfS quality management system (radioactive waste disposal)

The process management manual relating to waste package quality control ensures that the waste packages to be disposed of fulfill the relevant waste acceptance requirements.

Fig. 2 gives an overview on the radioactive waste-specific BfS quality management system.

BOUNDARY CONDITIONS FOR CONDITIONING

Disposal of radioactive waste presupposes the conversion of primary waste into defined waste packages, conditioning in such a way that the waste is suitable for emplacement in a repository in deep geological formations. In addition, documentation of the pre-treatment, processing and packaging steps including the repository relevant waste package characteristics must be provided.

Up to now, the boundary conditions for conditioning radioactive waste with negligible heat generation (i.e., low-level and intermediate-level radioactive waste) have particularly been provided by the Konrad waste acceptance requirements (as of December 1995) [3]. These requirements were prepared within the Konrad repository licensing procedure. The issue of the license completed this procedure on May 22, 2002. The license is still subject to court examination.

At present, a repository is not available in Germany and, consequently, no obligatory waste acceptance requirements can be defined. In practice, it turns out that the pre-treatment, processing and packing of radioactive waste with negligible heat generation is particularly performed according to the Konrad waste acceptance requirements and, as far as applicable, to supplementary restrictive requirements given in the Konrad license. These criteria, however, have to be applied in a flexible manner.

Specific important issues mainly result from possible chemical reactions/residual moisture content/gas generation, declaration of safety-relevant radionuclides, chemotoxic organic and inorganic constituents of the waste packages and documentation of disposal-relevant data.

PROCESS OF RADIOACTIVE WASTE PACKAGE QUALITY CONTROL

It is the task of radioactive waste package quality control to ensure compliance with the waste acceptance requirements. The technical measures taken can be split up in

- Control of waste packages by sampling inspections,
- Qualification and subsequent inspection of conditioning procedures,
- Control of radiation sources, and
- Design test of waste containers.

In the sampling inspection of waste packages as well as in the qualification and inspection of conditioning procedures, apart from disposal-specific requirements, requirements must be considered that result from the provisions for the respective nuclear facility and were established by the competent Federal State (Laender) authorities, e. g. for the interim storage of radioactive waste or for the operation of conditioning facilities.

The process and the responsibility assignment in radioactive waste package quality assurance/quality control still correspond to the recommendation given by the Laender Committee for Nuclear Energy (acknowledged by the main committee in December 1994). This recommendation still represents the basis for all respective quality assurance/quality control measures. The process of waste package quality control in connection with the respective tests and the areas of responsibility, tasks and activities of the parties involved are explained in detail in [4] and [5].

Standardized Process Control Quality Plans

On the basis of previous experiences in waste package quality control gained over many years the approved process control quality plans are still successfully applied, i. e. the procedures relating to the conditioning of radioactive waste are qualified by BfS (procedure evaluation) and approval is given by BfS for disposal-relevant waste characteristics and for waste package documentation. Qualification can either be campaign-related or campaign-independent. Standardized process control quality plans were developed and implemented for the necessary work and/or controls. In their essential steps they differ as follows:

(a) Campaign-related process control quality plan

- Announcement of a waste campaign and filing of a campaign specific process control quality plan, giving type and amount of the primary waste.
- Campaign-related control by BfS expert, evaluation of the procedure and certification of the process control quality plan.
- Approval of the process control quality plan by BfS.

- Conditioning on the basis of the approved process control quality plan with accompanying control by experts.

(b) Campaign-independent process control quality plan

- Filing of a standardized process control quality plan and transfer of data on the primary waste.
- Campaign-independent control by BfS expert, evaluation of the procedure and certification of the process control quality plan.
- Approval of the process control quality plan by BfS with respect to the procedure's suitability for producing waste packages that are suitable for being disposed of in a repository.
- Announcement of a campaign and filing of a stamped original of the standardized process control quality plan, providing information on type and amount of the primary waste.
- Control and statement of BfS expert with respect to the applicability of the procedure of processing the announced waste, certification of the stamped original.
- BfS approval of the waste campaign and of the stamped original.
- Conditioning on the basis of the approved process control quality plan with accompanying control by experts.

In radioactive waste package quality control the practice of using process control quality plans has successfully been applied for more than ten years in about 900 waste campaigns. With this procedure, compliance with disposal-relevant issues and also with the characteristics of the waste/waste streams and the technical conditions/boundary conditions of their conditioning is taken into account in an optimal way. Compared to this, there are only very few special cases where pure sampling inspection and pure procedure qualification (qualification and accompanying control of conditioning measures) are used to prove compliance with waste acceptance requirements. In connection with this, it should be mentioned that procedure qualification has only been applied for three times so far and was approved by BfS subsequent to the fulfillment of comprehensive pre-requisites.

Experiences gathered so far have given an impulse to further elaborate the practice of using process control quality plans. The decommissioning and dismantling of nuclear facilities should especially be mentioned due to the huge volumes of largely homogeneous radioactive waste that have to be conditioned over comparatively long periods of time. This led to the development of mixed variants between campaign-related and campaign-independent procedure qualification: the basic evaluation and approval of a procedure in a first step and, later on, the approval of application following a campaign-specific control. Another possibility is the campaign-independent evaluation and approval of a standard process control quality plan to process and to package primary waste that complies with established boundary conditions. Compliance with these boundary conditions must be proved and confirmed a short time before conditioning starts. This is to be done by accompanying controls and a timely exchange of information between the experts involved. This procedure was developed in the past two years. Since then its introduction has been started.

Progress in Waste Package Quality Control

The essential steps of the process of radioactive waste package quality assurance/quality control under current boundary conditions can be described as follows:

- Revision and inspection of the process control quality plan under disposal-related aspects by BfS and its experts.
- With the approval of the process control quality plan by BfS it is ensured that according to the present state of knowledge all measures are carried out in such a way that they are suitable with respect to disposal and that all repository relevant data are documented.

- On behalf of BfS, its experts prepare the inspection report on interim products and/or waste forms and/or waste packages. Using this report as a basis BfS makes a statement relating to
 - the correct execution of the commitments agreed upon in the process control quality plan
 - the proof of compliance with the waste acceptance requirements used as control measure or, depending on the single case, of certain parts of these requirements.
- On this basis, only those parts of future obligatory waste acceptance requirements that will go beyond this will have to be re-evaluated later on.
- When interim products are produced they are controlled and evaluated on the basis of the documentation. A statement is made about compliance with single requirements.

Conditioned radioactive waste (i.e., waste packages) that has been subject to quality control can only be accepted in a federal repository if they comply with future waste acceptance requirements. Such requirements may include additional requirements resulting from the safety-related planning work for a future repository in Germany.

This approach ensures that

- at present all disposal-relevant data are compiled and recorded in a qualified way,
- the produced interim product or waste form does not contradict the present requirements on radioactive waste to be observed,
- there will probably be no need for future inspections or sampling, e.g. for analytical investigations, which would involve great efforts,
- future measures which may become necessary within the scope of re-qualification or final conditioning steps should only cause radiation exposures as low as possible for the staff and the environment.

PRACTICAL EXPERIENCE

In view of the disposal situation described above, the period until a repository will be taken into operation is of great importance, too, for the waste pre-treatment and conditioning procedures applied in practice. Such procedures must aim at processing the primary waste into inherently stable, inert and dry interim products and/or waste forms and at packing them into corrosion resistant vessels or containers. The consideration of today's conditions and requirements, the involvement of technical boundary conditions and preconditions and also the fact that binding waste acceptance requirements cannot be established/are not available has thus led to a flexible practice in waste pre-treatment, waste processing and waste packing, in accord with a flexible application of the Konrad waste acceptance requirements [3] and including the respective specific waste package quality control measures [4]. The practical situation during the past years was as follows:

- Production of interim products and/or waste forms,
- Production of waste packages not in compliance with single requirements of the Konrad waste acceptance requirements,
- Production of waste packages in compliance with the Konrad waste acceptance requirements, and
- Production of waste packages in compliance with the Konrad waste acceptance requirements and other requirements (e.g., given in the Konrad license).

This practice is explained in the following, and corresponding examples of waste package quality control measures are described.

Interim Products / Waste Forms

Interim product and waste package characteristics being relevant for disposal are examined within the quality assurance/quality control system. BfS qualifies the conditioning methods and procedures (i.e., evaluation of the conditioning process) and confirms the disposal-relevant waste product/waste package characteristics as given in accompanying data sheets and being part of the documentation.

If only parts of the waste acceptance requirements are met, the approval for further conditioning steps is only given in a restrictive way. In such cases, e.g., lacking evidence or proof is still to be supplied or further examinations are still to be performed.

When producing interim products/waste forms, depending on the announced waste campaign, the following conditioning methods are applied:

- Treatment of radioactive waste to interim products which are either been packaged into 200 liter drums and combined to “virtual” waste packages (standardized Konrad containers) or put into waste containers without grouting.

If compliance with the requirements applying to the respective interim products can be proved, BfS confirms this and releases the products for further processing into waste packages suitable for disposal.

In single cases, compliance with the Konrad waste acceptance requirements cannot be confirmed without restriction. The following cases may occur:

- Exceeding of activity limits

Under certain circumstances described below, the performance of conditioning can be approved, although activity limits of the Konrad waste acceptance requirements are not observed:

- It is proved that the corresponding activity limits will be observed after a decay time of, e.g., 20 to 30 years.
 - By packing the waste forms into class-II waste containers or in so - called incident-proof containers compliance with respective activity limits is ensured.
 - The exceeding of activity values per waste package resulting from analyzing thermal effects on the host rock or from analyzing criticality safety is covered by specific emplacement techniques (mixed emplacement).
- Use of waste containers for which design approval must be concluded or carried out

For waste containers for which no BfS test certificate is available as a result of a successfully concluded design test, the performance of conditioning can be approved under the following conditions:

- Release is granted subject to concluding a running design test or carrying out a design test.
- It is proved that using an over-pack ensures compliance with specific waste container requirements.

Waste Containers

Meeting of container or packaging related requirements is basically controlled by:

- Design tests,
- Accompanying fabrication quality controls,
- Test and control measures in waste package quality control, and
- If necessary, tests on the waste packages.

The proof that a certain container type is suitable for disposal must be furnished within the scope of the design test. Waste containers are tested in close co-operation with the Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und -prüfung, BAM) being competent for the inspection and approval of packaging / packages according to Traffic Law.

Since 1998, altogether nine design tests were performed and concluded by a test certificate issued by BfS.

These design tests included the following standardized container types:

- Type I and II cylindrical concrete containers as packaging of waste container class I,
- Type IV concrete containers as packaging of waste container class I,
- Type IV cast-iron containers as packaging of waste container class II,
- Type IV sheet-steel containers as packaging of waste container class I,
- Type IV and VI sheet-steel containers as incident-proof and non-incident-proof packaging of waste container classes I and II,
- Type VI sheet-steel containers as incident-proof packaging of waste container classes I and II, and
- MONOLITH cast-iron containers (type VI containers of half the normal height) as packaging of waste container class I.

These design-tested container types are used as packaging for different types of radioactive waste within the scope of various campaigns:

- Type IV sheet-steel containers are used as packaging of waste container class I of building rubble arising from dismantling a nuclear power plant.
- For the packaging of fission products containing waste from fuel element fabrication type VI sheet-steel containers are used as incident-proof packaging of waste container class II.
- MONOLITH cast-iron containers are used as packaging for components of the reactor core and of parts of the reactor pressure vessel in the process of dismantling a nuclear power plant.

The design tests carried out so far have shown that it is difficult to furnish single proofs, especially for already fabricated containers.

It is, for example, partially difficult to prove the suitability of the material. In particular a failure due to brittle fracture at the demanded temperature of -20°C cannot be excluded. Therefore, only appropriate materials are used for newly fabricated containers. Taking into account appropriate measures, old containers can be released for disposal if the overall safety is not affected.

Another example of a requirement which is difficult to fulfill and which has to be applied to waste containers of waste container class II without specified tightness is the test alternative that the waste form does not reach a temperature of 80°C under thermal load (800°C over 1 hour and 24 hour cooling phase). The thickness of the heat-insulating layer leads to a very small usable volume. In practice it is rather shown that no relevant activity release occurs under thermal load.

Waste Documentation

A complete documentation is the basis for waste package examinations. When compiling this documentation it has to be assured that all relevant information on the waste being presently available are included in a traceable and unmistakable manner. Thus, a sound data basis will become available for future examinations even subsequent to periods of long-term storage. This should be understood as a contribution to reduce both the effort to meet future waste acceptance requirements and the additional radiation exposure to the staff. Thus, care is taken that in future - if necessary - additional (final) conditioning steps can be carried out as simply as possible avoiding significant radiation exposures and reducing respective technical measures.

SUMMARY

In the context of the present disposal situation in the Federal Republic of Germany the need for a flexible application of the Konrad waste acceptance requirements (considering, as far as applicable, supplementary criteria given in the license of the Konrad repository) as well as relevant waste package quality assurance/quality control measures becomes apparent. This involves a certain alignment towards waste characterization. That's the way the necessary details and data are to be determined which should already today be compiled and documented with respect to a future evaluation of the disposability. As a precaution it is therefore recommended to consider these requirements already now in the pre-treatment and/or conditioning of radioactive waste and to have their compliance tested and evaluated by BFS within the scope of waste package quality control.

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