
Note:
This is a translation of the RSK recommendation entitled
“Erfahrungen im Umgang mit der Corona-Pandemie – Methoden der Fernaufsicht/-inspektion”
In case of discrepancies between the English translation and the German original, the original shall prevail.

RSK recommendation

(524th meeting of the Reactor Safety Commission (RSK) on 20 October 2021)

Experience gained in dealing with the corona pandemic – methods of remote supervision/inspection

RECOMMENDATION

Contents

1	Background and introduction	2
2	Terms and definitions.....	2
3	Scope and assessment criteria	4
4	State of the art of remote supervision/inspection methods	7
4.1	Technical systems	7
4.2	Remote inspection applications	8
5	Assessment.....	9
5.1	Activity-specific assessment	10
5.2	General aspects	16
5.3	Aspects of safety culture and soft skills of the personnel	18
5.4	Advantages and disadvantages of remote inspection	19
5.5	Admissibility of permanent use of remote inspection methods	20
6	Summary	20
7	References	22

1 Background and introduction

In a letter dated 25 January 2021 [1], the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) asked the Reactor Safety Commission (RSK) for a statement on methods of remote supervision/inspection against the background of the corona pandemic:

The corona pandemic has posed new challenges for the licensing and supervisory authorities of the Federation and the Länder, the expert organisations and the operators. Numerous measures have been taken both to ensure the protection of employees and the performance of tasks in order to ensure nuclear safety. The BMU and the supervisory authorities of the Länder regularly exchange experience in dealing with the corona pandemic. One issue that has arisen not only between national authorities but also in an international context is the use of remote supervision/inspection methods to minimise contacts. This concerns both the activities of authority personnel and on-site activities of authorised experts, such as accompanying test participation of authorised experts in the context of recurrent tests.

I request the RSK to make recommendations regarding the applicability of methods of remote supervision/inspection from a safety point of view with regard to the type or subject of testing.

In this context, the respective advantages and disadvantages and the resulting possibilities and limits of the methods should be pointed out in comparison to on-site supervision, i.e. compared to presence and, if applicable, to other methods. In the assessment, I ask to differentiate between temporary (please under derived indication of the test intervals/test periods) and permanent application.

The experience gained so far in the context of the corona pandemic should also be taken into account.

In accordance with Section 9(1) of the Statutes, I request the RSK to submit a written recommendation by 10 September 2021.

At the 520th meeting of the RSK on 10 February 2021, the BMU explained the request for advice. The RSK decided to discuss the request for advice in an inter-committee ad hoc working group on the issue of remote inspection (AG Ferninspektion). In five meetings between 2 March 2021 and 10 August 2021, the AG Ferninspektion prepared the present recommendation with hearings of different institutions, which was adopted by the RSK at its 524th meeting on 20 October 2021. Thus, the RSK has concluded its consultations on the BMU's advisory request.

2 Terms and definitions

[in the order of the German original text]

Audit	Process for obtaining relevant information about an object (product, process, service, installation or its development) and evaluating it objectively to determine the extent to which the requirements specified for the object are fulfilled.
Construction supervision	Inspection of the manufacture or installation of equipment at the manufacturer's site or at the facility on site. Construction supervision is a specific type of accompanying control.

Walkdown	Visual examination of a system or part of a facility to determine compliance with the specifying documentation and general condition. This may include inspection of the relevant documentation. A walkdown can be part of the test scope of the facility as specified in the testing manual or can be carried out by the expert consulted and/or the authority on the basis of its own walkdown programme or on an ad hoc basis.
Accompanying control	Inspection of the performance of an activity at the operator's or manufacturer's site. This may include the activities of personnel and technical characteristics of equipment and processes.
Technical discussion	Verbal exchange of information, possibly supplemented by presentations or the handing over of documents, for example as an element of supervision or as part of audits.
Remote Inspection	Inspection activity without physical presence at the location of the inspected object.
Inspection	Examination of a product, process, service or installation or of its development and verification of its conformity with specific or, on the basis of expert judgement, with general requirements ¹ .
Testing	Determination of one or more characteristics of an object according to a procedure. In this context, a procedure is defined as a specified way of carrying out an activity or process.
Accompanying test participation	Participation in tests to be able to directly observe how they are conducted and which results are achieved. Accompanying test participation is a specific type of accompanying control.
On-site audit	The part of the audit that is performed on-site at the audited company. Note: DIN EN ISO/IEC 17021-1:2015 contains requirements for the performance of audits and the audit parts to be performed on site, including “remote access to electronic sites”.
Recurrent test	Control of equipment and systems of a nuclear installation to be carried out according to a specified schedule and test programme. The recurrent tests are carried out to check whether equipment and systems are in a condition that complies with the licence and fulfil their function reliably.

¹ This deviates from the KTA Collection of Definitions since in this statement the term inspection does not only include the examination of technical equipment but also of processes and services.

3 Scope and assessment criteria

As part of their tasks for supervision pursuant to § 19 of the Atomic Energy Act (AtG), representatives of the authorities and/or experts consulted participate in the following activities on site or carry them out on site themselves:

- walkdowns,
- inspection of documents,
- gathering of information on relevant operational processes,
- functional tests (recurrent tests and acceptance tests),
- non-destructive testing (recurrent tests and acceptance tests), also including pressure and leak tests,
- data recording / performance of measurements,
- accompanying controls at the operators' premises (e.g. accompanying test participation, construction supervision, waste management campaigns, loading of transport and storage casks),
- construction supervision at the manufacturers',
- audits (e.g. on management systems), and
- participation in technical discussions.

These activities are considered in this statement and it is analysed whether and how methods of remote supervision/inspection are applicable in each case. In this respect, no distinction is made as to whether the activities are carried out by experts consulted or representatives of the authorities since this is irrelevant regarding the possibility of carrying them out without on-site presence. In the following, the term "authorised experts" will include both the experts consulted and the representatives of the authorities.

In keeping with the defined terms, the inspection activities carried out by authorised experts can be summarised in three groups:

1 Participation in technical discussions

Verbal exchange of information, possibly supplemented by presentations or the handing over of documents, for example as an element of supervision or as part of audits

2 Testing by authorised experts

Independent determination of equipment characteristics by the authorised expert. This includes walkdowns during which the authorised experts carry out their own determination of characteristics.

3 Accompanying controls

Accompanying control is the inspection of an activity at the operator's or manufacturer's site. This includes the accompaniment of recurrent tests and construction supervision at the manufacturer's or at the facility, but also the inspection of operational processes such as the loading of transport and storage casks at the nuclear power plant. During the accompanying control, the authorised experts satisfy themselves of the execution of actions in accordance with the relevant instructions and of the compliance with specified technical values, which are determined – where necessary – by the personnel of the manufacturer, operator or their contractors. Accompanying control also includes many audit activities, insofar as the auditors do not carry out their own tests.

For the analysis in this statement it is necessary to further differentiate the activities in groups 2) and 3) since there are, for example, different requirements for different types of tests. This differentiation is made in the assessment in Chapter 6.

In its advisory request, the BMU requested the RSK to make recommendations regarding the applicability of methods of remote supervision/inspection from a safety point of view with regard to the test type or test object. In this context, the respective advantages and disadvantages and the resulting possibilities and limits of the methods shall be pointed out in comparison to on-site supervision, i.e. compared to presence and, if applicable, to other methods. The assessment should distinguish between temporary and permanent application.

§ 19 of the Atomic Energy Act stipulates that nuclear installations are subject to government supervision. It begins with the construction of the facility and extends over the entire operating period up to decommissioning and dismantling. In particular, the competent supervisory authority has to ensure that the operator does not violate the Atomic Energy Act and the ordinances based on it as well as the provisions of the licensing decision.

Walkdowns at nuclear installations are an essential means of government supervision. The walkdowns are carried out by employees of the supervisory authority and the authorised experts consulted. Through visual examination on site, inspection of operating records and own measurements it is to be determined whether

- the facility is operated in compliance with the licence and the provisions under nuclear and radiation protection law,
- the facility is in proper condition and the interaction of the various systems is functioning as designed, and
- appropriate preventive measures for radiation protection, fire protection and physical protection have been taken.

Recurrent tests are also carried out regularly on individual equipment or systems. The aim and purpose of the recurrent tests is

- the early detection of deficiencies that could affect safety, and
- maintaining the quality standard during the entire operating time of the facility.

The licences require the performance of recurrent tests to be carried out by the operator, in parts with the participation of authorised experts. The control of the recurrent tests by authorised experts serves to demonstrate that the operator has fulfilled his corresponding testing, surveillance, inspection and maintenance obligations.

In particular, this provides an independent

- confirmation that the testing has taken place as specified,
- confirmation that the original test results are documented, and
- assessment of the test results by the supervisory authority / authorised experts.

Based on the experience that contacts between persons should be limited as far as possible during pandemics, the question arises whether the above-mentioned objectives of supervision can be achieved with reduced on-site participation. It is to be assessed under which technical and organisational conditions this is possible.

With the further development of testing technology and, in particular, the possibilities for visualisation and storage of test results, it was already possible in the past to reduce the necessity for the presence of the authorised experts near to the test object. The minimisation of radiation exposure played a major role in this. Since there have been significant further developments in technology, especially with regard to online participation without on-site presence, alternatives to on-site participation are also to be re-assessed for this reason.

When using remote inspection, it is important that the independent test result can be produced with the same quality and reliability (stable data transmission, availability of IT systems, etc.) as with on-site presence. In the case of reduced quality and reliability of the remote inspection it is to be examined to what extent such a limited inspection is acceptable for a limited period of time. This then raises the question of how long remote inspections can be used as a partial substitute for inspections with on-site presence.

In the assessment, the RSK considered the following aspects:

- Recording and transmission of information and sensory impressions relevant for the inspection in suitable quality. When recording relevant information, it is to be taken into account whether it is documented automatically from the process or manually during the inspection. Furthermore, it is to be considered whether the information can be read out at any time or is only available on site during the activity. Depending on the type of inspection task, sensory impressions can include noises, temperatures, vibrations, odours, surface conditions and the visual impression of the condition of the facility or equipment but also the interaction of persons with regard to the safety culture.
- Necessity of synchronous interaction between the authorised expert and the personnel at the facility. Examples of synchronous interaction include information retrieval upon request by the authorised expert or the need for ad hoc confirmations from the authorised expert as a prerequisite for continuing the activity. This is typical for accompanying control of operational processes where a large number of control steps are performed in a continuous process and where deviations occurred are difficult to correct.
- Necessity of complex communication for the inspection where different types of information have to be followed, possibly in parallel and with interaction between the participants, or existence of a simple communication task where a few pieces of information, uniform in nature, are transmitted.
- Availability of a proven technology with a high degree of maturity for the communication task associated with a remote inspection. This concerns the hardware and software but also training and assistance in the application. Here, the extent to which additional requirements arise for the application of the technology, such as the security of the connection and the avoidance of malfunctions at the facility, is to be considered.

The individual inspection activities are assessed taking these aspects into account.

In addition, the following general aspects of remote inspection are considered:

- absence of repercussions on the facility,
- security of data acquisition and transmission,
- documentation of the test results,
- protection of personal data,
- requirements with regard to preparation, training and follow-up, and
- aspects of safety culture and soft skills of the personnel.

The advantages and disadvantages of remote inspection are qualitatively assessed in comparison to inspections with on-site presence. The admissibility of permanent remote inspection is summarised.

4 State of the art of remote supervision/inspection methods

During the meetings of the ad hoc working group, developments, applications and experiences with remote inspections were reported on by

- the plant manufacturer Framatome [2],
- the operator of the Brokdorf nuclear power plant [3],
- the expert organisations TÜV Association (TÜV Verband) [5], [6], SVTI (Swiss Association for Technical Inspections) [7] and TÜV NORD [8],
- the Schleswig-Holstein Ministry of Energy, Agriculture, the Environment, Nature and Digitalization (MELUND) [4], and
- the central authority of the Länder for safety technology (Zentralstelle der Länder für Sicherheitstechnik – ZLS) [9] as the competent authority for the authorisation of inspection bodies in the conventional sector.

4.1 Technical systems

Typically, the following systems are used in remote inspections:

- imaging inspection methods by means of a camera, ultrasonic recording,
- data transmission of measurements or incoming signals, and
- video signals for communication.

Data transmission takes place via LAN, WLAN or radio network. According to the experiences presented, the data transmission rates are generally sufficient for the data obtained. Usually, the possibilities for secure data transmission from the controlled areas had to be created first in the realised applications.

The spectrum of cameras ranges from smartphone cameras to high-resolution special cameras, depending on the intended use. Data transmission via WLAN or radio network is standard for all types of cameras. In most cases, a LAN connection is also possible.

Cameras can be used both stationary (if only a certain field of view is required) and mobile for visual inspection of different areas. If required, the cameras can also be integrated into devices such as pipe pigs, crawlers or drones.

By streaming several video signals, discussions can take place with several experts or an integral overall view, several partial views and also details of a test location and test object can be shown.

One application currently being tested are so-called smartglasses, in which the camera and display as well as the voice transmission are integrated into a glasses frame. With augmented reality functions, objects can be marked or attention can be directed in a specific direction via virtual pointers. Circuit diagrams, notes or examples of action can also be displayed. Thus, assistance can be provided remotely and the process can be monitored at the same time.

The test results (e.g. of ultrasonic and eddy current tests) are usually digitally recorded and stored. The evaluation generally takes place after the test, so far mostly on site (e.g. in measuring containers). Synchronous data transmission from the facility and thus live tracking is principally possible. These systems are state of the art.

In the case of X-ray tests, the results are documented on data carriers (e.g. films), often also digitised. The results are therefore only available after the test has been carried out, and the evaluation takes place in external rooms, for example of the operator or the authorised experts. In this respect, there are therefore no restrictions either regarding the evaluation of the test result (state of the art).

During the functional tests in nuclear power plants, measurement data and messages are generated that are usually recorded and stored via computers. These data can be forwarded synchronously or asynchronously. Depending on the integration of the computers into the operator's operating system, measures are to be taken for security against malfunctions and for IT security.

Tools that can digitally record, log and transmit settings/measured values, such as digital torque wrenches, are currently being tested.

4.2 Remote inspection applications

For technical discussions and conferences, video systems are used that offer a high level of comfort and stable performance and are also suitable for a larger number of participants. With the fading in of presentations, it is also possible to present texts, images or documents to all participants in good resolution. Chat functions in which questions or comments can be entered, division of groups into chat rooms and quick visualisation of discussion results are helpful additional functions. Many systems with good performance are available on the market.

Camera systems are used as standard for specific visual inspections. This applies, for example, to video endoscopy as well as to pigs for the internal inspection of pipes. These data can generally also be transmitted online.

Camera monitoring has been in use for some time now in connection with core loading. The correct core loading can be checked in the recordings.

For other visual inspections such as leak tests, dye penetrant or magnetic particle testing as well as inspections of the condition of components or in the context of construction inspections, the use of camera systems has not been standard yet. In the context of the corona pandemic, however, camera systems were also used in some cases ranging from smartphone cameras to data glasses, especially in the context of quality control inspections at manufacturers'. This is often practised so that not all inspectors have to be on site and the correct performance is monitored there, but a more detailed assessment is then carried out externally by inspectors with special expertise. According to the presenters, image quality and data transmission rate were sufficiently high for the cases in question.

As already explained in Chapter 4.1, the data of mechanised non-destructive tests (e.g. ultrasonic and eddy current tests) are digitally recorded and stored. Synchronous data transmission outside the facility and thus live tracking and external evaluation is possible. However, it is sufficient if the data are transmitted after the test. If such a data transmission is accepted, the evaluation can take place at any location without any loss of quality.

According to the current state of knowledge, measurement data from tests in the facility are usually not transmitted online outside the facility. In individual cases, the results achieved are transmitted as a report, printout or photo via the usual digital media such as emails. During the corona pandemic, however, there were also examples in which the data from mechanised non-destructive tests were successfully transmitted to an external location and evaluated there.

In Germany, the collection of measurement data is mandatory for monitoring possible emissions from nuclear power plants. For this purpose, the remote monitoring system for nuclear reactors (Kernreaktor-Fernüberwachung – KFÜ) is used. These data are transmitted to the supervisory authorities and can be viewed synchronously. An evaluation of the recorded data is also possible externally.

The ZLS reported that due to the corona pandemic, technical aids (e.g. endoscopes, drones) were being used in the conventional area for facilities requiring monitoring. However, they were only used to supplement or support the inspection of difficult-to-access locations and parts of a facility. On-site inspections were not replaced by these supplementary inspections. For inspections in its area of responsibility, the ZLS requires the presence of the inspector on site since the inspector in this area of responsibility carries out the inspection personally and is responsible for the inspection result.

5 Assessment

In the following, the three different groups of inspection activities, as defined in Chapter 3, are considered. First, the objectives of the inspections are presented, if necessary, with a differentiation depending on the inspection activity or the type of inspection. Then, the inspection activities are assessed on the basis of the

criteria developed in Chapter 3. Finally, the advantages and disadvantages and the general aspects of remote inspection are considered.

5.1 Activity-specific assessment

1 Technical discussion

Technical discussions are usually a synchronous exchange of information with several participants, often involving complex communication. Proven commercial technical solutions are available for video conferencing. Technical discussions as elements of supervision or inspection can thus also take place without personal participation on site. The non-verbal component, which is particularly important for the interaction of a group, can only be recorded to a limited extent. This can play a role in the assessment of the safety culture.

2 Testing

a Walkdowns

The objective of walkdowns usually is to gain an overall impression of a system with the surroundings in the facility. With today's common camera systems or data glasses, only partial acquisition of the required visual information is possible. Other sensory impressions cannot be gained. The walkdown covers different locations in the facility, which would require the use of several cameras to capture the overall situation in the facility, thus making remote inspection difficult. Interaction with the personnel in the facility is required to support the walkdown and clarify issues, although this usually does not involve complex communication. Noise in the facility can nevertheless make communication difficult during a remote inspection.

Overall it can be stated that generally replacing on-site walkdowns by remote inspections is not recommended due to the above-mentioned limitations. Remote inspection can be carried out in individual cases for specific inspection tasks or the involvement of additional experts with special knowledge.

b Technical tests on an object

In nuclear technology, independent technical tests by an authorised expert are not the rule since tests by the operator or the manufacturer are in general accompanied by authorised experts. An exception are manual non-destructive tests, in particular manual ultrasonic tests, for which independent tests by the authorised expert may be required within the scope of the accompanying test participation. This is dealt with in the section on non-destructive tests under 3) b.

If independent technical tests by the authorised expert are required, for example to establish a fact in the context of a reportable event, these cannot be replaced by remote inspections, since it is precisely the independence of the test that is essential then.

3 Accompanying control

a Construction supervision

Participation in activities related to manufacturing, assembly or repair is referred to as construction supervision. Usually, the steps requiring supervision are specified in a construction inspection plan or quality plan. Construction supervision in a project may extend over a longer period of time, with the experts being invited for the steps they are to supervise.

The steps requiring supervision can be divided into the following groups for assessment with regard to suitability for remote inspection:

Control of manufacturing documents, certificates, attestations

- Manufacturing requirements of the manufacturing plants
- Inspections of incoming materials or semi-finished products
- Qualifications of the inspectors or welders
- Calibration of work or test equipment
- Documentation reviews

These reviews are limited to checking the completeness and formal correctness of the above-mentioned documents and confirming compliance with the persons, materials or work equipment listed. This information can be exchanged digitally without any problems, and verification is possible with the camera systems commonly used today.

Participation in manufacturing steps

- Heat treatment steps
- Non-destructive tests
- Welding work
- Mechanical-technological tests

Heat treatment steps can be monitored well by remote inspection. Monitoring the placement of a component part in the furnace and the correct placement of the thermocouples can be conducted easily with today's common camera systems. The temperature curves are recorded by means of chart recorders or data loggers and can be viewed afterwards.

Non-destructive tests are considered separately in detail under 3) b. In the context of construction supervision, the two sections dealing with tests at the facility and tests at the manufacturers' are relevant.

The welding work and the mechanical-technological tests can be classified similarly to the manual test methods of non-destructive testing (NDT). Presence on site enables the recording of skills,

experience and competence of the personnel to an extent that is hardly possible to achieve through remote inspection.

Independent performance of steps

- Restamping of materials during manufacture

Restamping of materials or semi-finished products is carried out personally by the authorised expert by hard-stamping and can only be done on site. Remote inspection is not possible.

Factory acceptance test

After completion of manufacture, assembly or repair at the manufacturers', a factory acceptance test is usually carried out before the respective components are delivered to the facilities. The proper condition and, as far as possible, the function of the components are checked with the participation of an authorised expert. The methods of non-destructive material testing described under 3) b. and the functional tests described under 3) c. are primarily used here. With regard to the application possibilities of remote inspection, the possibilities and restrictions described there apply.

Summary assessment

The control of documents used on site can be carried out by appropriate means of remote inspection. Participation in manufacturing steps is usually only feasible with a loss of information via remote inspection. At manufacturers' who have authorised experts involved in the process as permanent representatives on site, these experts could perform a monitoring function that makes it possible involve further authorised experts for certain manufacturing steps via remote inspections.

b Participation in non-destructive testing (NDT)

The different types of NDT include

- visual examination (direct and indirect, for example by means of endoscopy, inspection robot),
- leak test (bubble test with sprays, helium leak test),
- pressure test,
- magnetic particle examination,
- dye penetrant testing,
- ultrasonic testing methods,
- eddy current testing methods, and
- radiography (X-ray examination).

NDT is applied in different situation, which are distinguished as follows.

Test after manufacture, assembly or repair at the site of the facility

This is always an initial test of the component. The tests and test methods are specified in detail during the examination prior to manufacturing processes. Nevertheless, it is inevitable that adjustments must be made on site to both the manual and mechanised tests due to the structural conditions or contours of the area to be tested.

Especially in the case of manual test methods, the handling of the test equipment has a significant influence on the test result. In the case of mechanised testing, the set-up of the test equipment and the choice of probes, often iterative, are of high importance during the initial test.

With the remote monitoring methods, monitoring of these tests is only possible to a limited extent, and it is not possible for the authorised expert to carry out own tests if this should be required for the independent confirmation of test results. Therefore, such tests should be accompanied by authorised experts on site.

Manufacturing tests at the manufacturers'

Here, a distinction can be made between the individual manufacture of components and the mass production of component parts of the same type.

In the case of individual manufacture of components, the statement on manufacture at the operators' applies equally. In the case of complex component parts with many processing steps, specialised authorised experts can be consulted for certain test steps by means of remote inspections. The video or recording technology required for it is available on the market and meets the requirements for the quality level required.

In the mass production of components (fuel rod cladding tubes, small valves and fittings, etc.), standardised or automated test procedures are usually used for testing. Synchronous communication is not necessary. The recorded test results can be viewed afterwards. Camera recording can also be used to monitor the correct assignment of test object and documentation of the result. The technical possibilities for this reflect the state of the art. Thus, remote inspection could be applied here.

Recurrent NDT at the facility

For recurrent NDT, test instructions are available that describe the test objective, test method and test procedure in detail. The test locations can be variable.

In the case of manual tests, the handling of the test equipment also plays a significant role in the test result to be achieved. The perception of the person conducting the test is also of importance. Camera systems and the associated external control by an authorised expert are only partly state of the art. For simple leak tests and surface crack examinations (dye penetrant and magnetic particle testing), remote inspection could be performed with camera systems, which are also

available in accordance with the state of the art. In principle, this also applies to all visual inspections. Ultrasonic NDT requires great experience in guiding the probes and, depending on the indication, also repeated changes in the positioning. For this reason, this is also conducted by the authorised experts themselves, and these examinations are not suitable for remote inspection. In radiography, the films can be evaluated digitally. The position and adjustment of the films and tubes can only be checked by remote inspection to a limited extent.

In the case of mechanised tests, the test result is recorded and can be transmitted to the authorised expert via data cable online or via data carriers afterwards. The assignment of the recording to the correct test location can be checked via a camera system or an authorised expert who is permanently present at the facility. As a rule, synchronous communication is not necessary. The necessary test and communication systems are state of the art. Remote inspection could be applied here.

c Participation in functional tests of process engineering/control systems

The functional tests of process engineering systems include, for example, tests of the

- function of valves such as gate valves and globe valves (opening, closing, tightness),
- function of pumps (start-up, flow rate, zero flow head),
- function of diesel generators (start-up, output, stability, temperatures, vibrations),
- function of control rods (rod insertion time, travel time, current consumption),
- function of control systems,
- function of measuring instruments, and
- function of signals/messages and actuation options.

In the case of functional tests, a distinction can be made between tests with a few displays and complex test scopes.

Functional tests where the results can be recorded and documented via displays at the control room and recording of the required values via computer systems are among the least complex tests. The values of displays, for example at the control room, which are no longer present after the test, are to be communicated synchronously. In the case of remote inspection, camera systems are required to make this possible. This could also be done by an authorised expert at the facility if an authorised expert with specific knowledge is to be consulted via remote inspection. Values that are recorded usually do not have to be communicated synchronously. Flow rate behaviour, time curves, etc. can also be transmitted after the test has been carried out. Each computer log also contains a “time stamp”. Camera systems and computer systems including transmission of data are state of the art, thus, remote inspection could be used for less complex tests.

Functional tests with complex test scopes, such as the testing of diesel generators, also require sensory impressions of vibrations, sound and temperatures. Some test values, such as power curve, which are also documented via computer, can also be transmitted asynchronously. As a rule, such tests should be

fully accompanied on site by an authorised expert for an integral assessment. If necessary, other specialists can be consulted for detailed aspects via remote inspection. These statements apply equally to factory acceptance tests and commissioning tests.

d Inspection of operational processes in nuclear installations

The inspection of operational processes in nuclear installations has similarities to construction supervision. Different activities have to be accompanied, some of them over longer periods of time, sometimes in three-shift operation, as for the loading of transport and storage casks for spent fuel. The work takes place in a limited spatial area, yet the relevant information can occur at different locations. There may be an alternation between recording the overall impression and the technical details. This applies, for example, to the loading of transport and storage casks. In other cases, for example at clearance measuring devices, the perspective changes only slightly. Synchronous interaction between the authorised expert and the personnel at the facility is required in many cases. The communication is often complex due to the observation of parallel processes and the interaction with different persons.

With the available camera systems and transmission techniques, visual information can be transmitted reliably. Communication with the personnel on site has limitations due to noise interference and reaches its limits when communicating with different persons.

Accordingly, the possibility of inspecting operational processes in the facility depends on the complexity of the process:

- For less complex activities, remote inspection is possible.
- For complex activities, remote inspections are not an equivalent substitute for an on-site inspection.

For the various operational processes, it would therefore have to be examined whether participation by remote inspection is reasonable and reliably possible. As with other activities, experts with specific knowledge can be consulted per remote inspection without requiring their presence on site.

e Audits

In Section 2, audit was defined as a process for obtaining relevant information about an object and evaluating it. An audit can therefore include different types of inspections, such as technical discussions, inspections of equipment and processes or also own tests. These types of inspections have been evaluated in the previous sections with regard to the possibility of using remote inspections. The statements derived also apply to the use of remote inspections as part of audits.

In nuclear practice, audits are often used to assess the management systems of operators and the qualification of manufacturers. As far as these are technical discussions with exchange of information, video conferencing systems can be used under the restrictions mentioned above. In contrast, during the initial assessment of a manufacturer's qualification, it is necessary to obtain an overall impression of the manufacturing site and the processes as well as the qualification and interaction of the personnel. Due to the complexity of the task, remote inspection methods are therefore not suitable to replace an on-site audit in this case. In the case of follow-up audits at a known manufacturer or at operators, remote inspections may be possible by way of exception.

5.2 General aspects

With regard to the general aspects mentioned in Chapter 3, the RSK comes to the following conclusions:

1 Absence of repercussions on the facility

The use of additional devices and communication links must not have any inadmissible effects on the operation of the facility. The setup of the devices and/or communication links may require modification procedures depending on the installation location in the facility. In particular, inadmissible repercussions on the safety of the facility's IT systems requiring protection in accordance with the guideline for the protection of IT systems in nuclear installations against disruptive action or other interference by third parties (SEWD-Richtlinie IT) and due to electromagnetic influences of the devices/communication links used are to be excluded.

2 Security of data acquisition and transmission

From a safety point of view, it is necessary to securely transmit the determined facts that form the basis of the test result of the remote inspection. For this purpose, it is additionally required, compared to an on-site inspection, that the information and data transmitted to the inspector are secured against alteration or that any alteration can be reliably detected. This must include both the recording of the information and data on site and the integrity assurance on the transmission path. For the transmission path, the confidentiality of the transmitted information must also be ensured, depending on the test object.

In order to determine appropriate measures for integrity assurance, the types of data transmitted are to be distinguished:

- Video/voice transmission:

Since this transmission is interactive between the communication participants and thus a change in the data transmission is reliably detected, special measures for integrity assurance are not required. When performing specific controls by means of a camera (displayed messages, visual inspections of components), the inspector must first verify the test object or the display device by means of other camera views (e.g. room view, display of component labels, test setup).

- Data transmissions:

In order to be able to reliably detect falsification of data, the integrity of the transmitted data is to be ensured. In the case of data sent in a block, this can be done by means of a transmitted signature (hash value), which can be used by the recipient to easily check the integrity of the data. In the case of online data transmission, a secure transport channel with encryption should be used in which the authentication of the communication partners takes place in addition to integrity assurance. To ensure that the transmitted data have been correctly recorded, measures are to be defined in each individual case. In the case of data that have been logged directly in a system for testing, suitable information for verification may already be included.

A second aspect is the confidentiality of the transmitted information and data, i.e. to secure them appropriately on the transmission path against access by unauthorised third parties. Some integrity assurance measures, such as encryption, also provide confidentiality protection. Confidential transmission of video data in a communication link is only possible with great effort according to the current state of the art. With regard to protection against access to the transmitted information and data, it is to be ensured that the requirements of plant security are met. For example, no information on security measures in the facility may be disclosed to unauthorised third parties.

The third aspect of IT security, i.e. availability, is of secondary importance for remote inspections by authorities and authorised experts in terms of safety since the function of the safety systems in the facilities does not depend on the communication with external parties. However, during inspections where synchronous interaction between operator and authorised expert is required, delays in the processes and thus additional costs can occur if communication fails. For such tasks, the reliability of data transmission is to be considered when deciding on the use of remote inspections. It should be specified in advance how to deal with disruptions in data transmission.

3 Documentation of the test results

In the case of remote inspections, the authorised expert cannot certify documents on site. Therefore, possibilities are to be created to document inspection results in a document-proof and tamper-proof manner. Digital signatures are a suitable tool for this purpose.

4 Protection of personal data

When carrying out remote inspections, the protection of personal data in accordance with the law is generally also to be observed. However, as this issue does not concern any safety-relevant aspects, it will not be dealt with in more detail here.

5 Requirements with regard to preparation, training and follow-up

Experience gained, among others, during the corona pandemic shows that appropriate preparations, including training, are needed for the safe and efficient application of remote inspection methods when

using new methods or introducing new processes. Special arrangements may also need to be made for follow-up measures.

In this context, the following is to be mentioned in particular:

Devices

If devices are used that are state of the art and widely available, no additional purchases are necessary. If specialised systems are required, for example video systems with overview camera and detail camera, lighting systems, video glasses, communication devices, etc., this can result in considerable additional expenditure. Before using such systems for the first time, their suitability must be checked in a functional test, and the use of the equipment must be trained accordingly.

Preparation

In the run-up to a remote inspection, it is to be clarified which information is to be transmitted, and the planned sequence of actions is to be discussed in detail. If necessary, complex steps must be practised in advance, and criteria for interrupting the remote inspection must be defined.

Follow-up

If not all information is transmitted online, the required data must be compiled by the operator and transmitted to authorities and authorised experts. Experience shows that this requires more effort. In addition, the test result from the authorities and authorised experts will only be available with a delay. On the other hand, the long-term availability of the transmitted and stored data is an advantage.

5.3 Aspects of safety culture and soft skills of the personnel

Safety culture and soft skills refer to aspects of interaction and communication between the operator's or manufacturer's personnel, cooperation and collaboration between employees, to aspects of leadership and the practised leadership processes in terms of safety, mindfulness and continuous learning. The safety culture is reflected in the lived values and standards (with regard to the prioritisation of safety aspects, the consistent application of and compliance with rules and regulations, but also safety-oriented thinking) and in the way people interact with each other.

The way of dealing with each other (leadership, communication and interaction) can also be recorded to some extent via video conferencing systems. In situations with complex communication, however, the possibility of recording via video conferencing systems quickly reaches its limits because, among other things, the non-verbal aspects of communication cannot be perceived or can only be perceived to a limited extent.

Safety culture also includes the management with regard to maintaining competence and know-how (see RSK statement “Monitoring of know-how and motivation loss and suitable measures for strengthening motivation and maintaining know-how in the German nuclear energy industry” of 3 November 2016). With regard to the competence management of soft skills and safety culture-related behaviour, the documents and the systematics with which, for example, the training and qualification programmes are followed up can also be discussed within remote inspection via video conference systems in order to prevent a loss of know-how.

It is more challenging to find out about such safety culture-related aspects that can only be captured through a direct overall perception of the conditions in the facility – such as conditions with regard to cleanliness, orderliness, well-kept premises – in the sense of visual appearance and the overall impression of the facility. This holistic impression of the condition of the facility cannot be captured, realised and evaluated by the currently available technologies.

In summary, the aspects of safety culture and soft skills cannot be captured by remote inspection to the same degree as with on-site presence.

5.4 Advantages and disadvantages of remote inspection

As pointed out in the assessment of the individual types of inspection and with regard to the general aspects, remote inspections have the following fundamental disadvantages from a safety point of view:

- limited perception of technical issues, especially lack of an overall impression of the situation on site,
- limited communication, especially when complex communication is required or in the presence of background noise,
- lack of personal contact with the performers,
- higher demands on the experts' ability to concentrate,
- additional precautions to ensure that there will be no repercussions on the facility and data security, and
- dependence on the availability and function of the technical equipment for recording and communication.

On the other hand, however, remote inspections also have fundamental advantages:

- reduction of the risk of infection,
- independence from travel disruptions caused, for example, by severe weather conditions or strikes,
- possibility of consulting experts with specialist knowledge for individual test steps,
- flexibility in the use of authorised experts, for example if an expert is not available due to illness,
- reduction of radiation exposure, and
- better processing and possibility of data storage and thus also accessibility for subsequent reviews.

The extent to which the individual advantages and disadvantages actually will be relevant for specific tests depends on the respective boundary conditions. Therefore, an assessment is required depending on the boundary conditions as to whether the advantages of remote inspection outweigh the disadvantages. In this respect, it is also important whether the inspection is to be carried out once, at intervals or permanently as remote inspection. A structured process should be used for this assessment, in line with the requirements for dealing with opportunities and risks in management systems.

5.5 Admissibility of permanent use of remote inspection methods

The admissibility of the permanent use of remote inspections instead of on-site tests essentially depends on whether the same quality can be guaranteed in all aspects for obtaining a reliable test result as with an on-site test.

Participation in technical discussions can be maintained on a permanent basis by means of remote inspection.

Most tests are subject to more or less severe limitations of various kinds. Tests with minor limitations – for example tests with less complex processes, automated tests, tests with automatic recording of results – can be set up permanently for remote inspection if the limitations are compensated for by occasional on-site participation. It may also be possible to obtain corresponding information during other tests of the same test object, for example through walkdowns.

Tests in which parts of the test can only be assessed to a limited extent from a remote location can be set up permanently for remote inspection if these parts of the test can be confirmed, for example, by an authorised expert other than the expert on site. Nevertheless, it is also expedient here if the authorised experts occasionally convince themselves on site that the test performance meets the requirements.

Tests in which parts of the test are not accessible to remote inspection and are necessary for the overall impression of the authorised expert should not be set up permanently for remote inspections. Among other things, this may be due to the lack of sensory impressions. Nevertheless, remote inspection is admissible in exceptional cases while examining the individual case. The prerequisite for this is, in particular, that the authorised experts have already accompanied this test in the past. The next test should, however, take place on site again.

With regard to a permanent use of remote inspections within the framework of supervision, an additional aspect to be considered is that the lack of presence on site weakens the perceptibility and effect of supervision vis-à-vis the operator's personnel. The possibility of exchange between authority staff and the authorised experts consulted with the operator's personnel is also limited, which means that less information is exchanged informally. Remote inspections can therefore not fully replace on-site presence.

6 Summary

In its letter dated 25 January 2021 [1], the BMU requested the RSK against the background of the corona pandemic to issue recommendations regarding the applicability of remote supervision/inspection methods from a safety point of view.

On the basis of the consultations of the ad hoc working group on the issue of remote inspection set up for this request, the RSK comes to the following summarised results:

- Remote inspections are used today in different technical areas and for different tasks. Due to the corona pandemic, there is increasing experience with remote inspections, although their limitations have also become apparent.

-
- The possibilities of using remote inspections depend on
 - the possibility to collect and transmit the information and sensory impressions relevant for the inspection in an appropriate quality,
 - a simple communication task between the parties involved,
 - the sufficiency of asynchronous, time-delayed interaction between the authorised expert and the personnel in the facility,
 - the existence of a proven technology for the inspection task, and
 - the exclusion of adverse repercussions on the facility by the technology used.
 - Against this background, the RSK regards remote inspections as generally admissible for specific monitoring tasks of the authorities and authorised experts, in particular for the following activities in supervision and inspection:
 - participation in technical discussions,
 - monitoring of mechanised test procedures of non-destructive material tests and functional tests with automatic recording of test results,
 - monitoring of functional tests, activities in the facility and manufacturing steps with simple processes and low spatial variability, and
 - documentation reviews.
 - The main disadvantages of remote inspection are the lack of a holistic impression of the situation on site and limited communication with the operator's or manufacturer's personnel. On the other hand, there are advantages such as protection against infections and greater flexibility in the use of authorised experts. The result of weighing up the advantages and disadvantages depends on the specific circumstances of the inspection task.
 - In specific cases, the disadvantages of remote inspection can be compensated for by a combination of on-site deployment of an authorised expert stationed at the facility and the involvement of the subject matter experts for the respective tests via remote inspection.
 - Whether remote inspections can replace inspection on site – in individual cases, at intervals or permanently – is also to be assessed for the specific inspection task. This may also take into account other on-site tests used, for example, to gain a holistic impression of the situation in the facility. A structured process should be applied for this assessment.

Thus, the RSK comes to the overall conclusion that, given the current state of the art, remote inspections can replace on-site inspections for a part of the inspection tasks, depending on the specific circumstances, temporarily or even permanently.

7 References

- [1] Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit
Beratungsauftrag
Erfahrungen im Umgang mit der Corona-Pandemie – Methoden der Fernaufsicht/-
inspektion
Aktenzeichen S I 3 – 1701/008 vom 25.01.2021

- [2] E. Wendenkampf, Framatome
Möglichkeiten und Erfahrungen mit Methoden der Ferninspektion aus Sicht des
Anlagenherstellers
Kopien der auf der 2. Sitzung der AG FERNINSPEKTION am 12.04.2021 gezeigten
Folien

- [3] U. Jorden, Preussenelektra
WKP im KBR unter der vorherrschenden Corona-Pandemie
Kopien der auf der 2. Sitzung der AG FERNINSPEKTION am 12.04.2021 gezeigten
Folien

- [4] M. Vogel, MELUND
Sachverständigenteilnahme an WKP im atomrechtlichen Aufsichtsverfahren unter den
Randbedingungen COVID-19
Kopien der auf der 2. Sitzung der AG FERNINSPEKTION am 12.04.2021 gezeigten
Folien

- [5] S. Vehring, TÜV-Verband
Konformitätsbewertung Remote-Tätigkeiten
Kopien der auf der 2. Sitzung der AG FERNINSPEKTION am 12.04.2021 gezeigten
Folien

- [6] S. Vehring, TÜV-Verband
Konformitätsbewertung – Remote-Tätigkeiten
Berlin, 23. Februar 2020

-
- [7] M. Scherrer, SVTI
Darstellung der Erfahrungen bei der Nutzung von Methoden der Ferninspektion als Sachverständiger in der Schweiz
Kopien der auf der 2. Sitzung der AG FERNINSPEKTION am 12.04.2021 gezeigten Folien
- [8] TÜV NORD REMOTE INSPECTION
Kurzeinblick in technische Möglichkeiten für die 3. RSK-Arbeitsgruppe Ferninspektion
Vortragsfolien für die 3. Sitzung der AG FERNINSPEKTION am 04.05.2021
- [9] Remote Inspection aus der Sichtweise der ZLS
Zentralstelle der Länder für Sicherheitstechnik (ZLS)
Vortragsfolien für die 3. Sitzung der AG FERNINSPEKTION am 04.05.2021