OPERATIONAL INSPECTIONS

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Quality assurance of qualified equipment consists of set of planned and systematically realized activities that are necessary to provide satisfactory self-assurance that the qualified equipment satisfies settled requirments and its quality.

Operational inspections of qualified equipment belong among such activities.

One of the inspections is operational inspection of reactor pressure vessel performed from inside.

This inspection is performed using following device:

- Supersonic system SAPHIR (SAG is the Manufacturer)
- Central pillar manipulator ZMM-5 (SAG is the Manufacturer)

It is necessary to have available experts for following activities to perform the inspection:

- chief of the inspecting group
- head of the shift
- operator of ZMM-5 manipulator
- expert supervision of data processing
- data processing
- data collecting

The inspection are realized by working team that consists of SE EMO and SAG employee and beginning from 1997 also SE EBO employee.

Description of ZMM-5 manipulator

The central pillar manipulator ZMM-5 is an equipment designed to perform inspection of reactor pressure vessel from inside. Following activities are available using the manipulator:

- crack detection control by ultrasonic and whirling currents
- visual check of surface
- repair works on reactor pressure vessel
- hardness measuring

The works are performed on cylindrical part in area of nozzles and in reactor pressure vessel bottom area using special modules position of which is ensured by ZMM-5 manipulator.

Massive construction of the manipulator enables the manipulator to be used also for other activities at inspection and repair works on reactor pressure vessel. The manipulator can also be used like universal carrier of measuring device and other tools.

ZMM-5 manipulator consist of following main parts:

- bridge of manipulator
- cable container
- pillar segments
- SIMACON control mechanism
- auxiliary parts

Each of the above parts is an individual unit dimensions of which enable their passage through material controlled area of nuclear power plant and they can be transported in standard euro-containers.

Following are further auxiliary parts of ZMM-5 manipulator :

- 20 ft and 40 ft euro-containers
- auxiliary bridge of the manipulator
- reactor pressure vessel model and auxiliary construction

Auxiliary bridge of the manipulator

Auxiliary bridge of the manipulator is an special one-purpose equipment that is necessary at performing automatic inspections of reactor pressure vessel of VVER 440 nuclear power plant by ZMM manipulator.

The auxiliary bridge is located on fuel loading machine rails in such a way that it bridges the reactor shaft. The manipulator bridge, cable container and service truck are located above the reactor laying on the auxiliary bridge upper rail that are oriented perpendicularly to fuel loading machine rails axis.

Location of whole equipment on rails of two perpendicular axes enables centralizing the manipulator pillar into reactor pressure vessel axis.

Reactor pressure vessel model and auxiliary construction

Reactor pressure vessel model and auxiliary construction serves for repair, maintenance and training run of ZMM-5 manipulator. The auxiliary construction enables to arrange the manipulator in the same way as on the auxiliary bridge at real works. The reactor pressure vessel model forms simulation environment for manipulator testing, development and construction of testing systems and software. It serves also for functional and integral tests performing.

Inspection of reactor pressure vessel

1) Phase of inspection preparation
2) Performing inspection
3) Final phase of inspection

1) Phase of inspection preparation

Following activities should be assured respectively realized during this phase :

a) Contract on the inspection
b) Specification of the inspection scope
c) Allocation of obligations to suppliers
d) Definition of fulfillment criteria (scope, time, quality,...)
e) Preparation of equipment - assure operating equipment for the inspection performing (realize repair, preventive inspection of all parts and systems). Accomplishment of each activity is recorded into check sheet and it is signed by worker that have performed the activity
f) Preparation of personnel for reactor pressure vessel inspection. Participation of experienced personnel begins already on starting works. The personnel know the plan and it participate on entire phase of preparation.
g) Phase of preparation is finished by integral tests. The equipment (manipulator, measuring and data processing system) is totally tested in scope corresponding to intended inspection during the integral tests. Activities are accomplished on reactor pressure vessel model that corresponds to real dimensions of reactor pressure vessel. Etalons with for purpose defects are used at integral tests. Each operation that will be performed during real inspection is tested during integral tests.
h) Integral tests evaluation is finished by protocol on performed tests.

2) Performing inspection

a) Required scope of inspection is defined in inspection specification. Usually following controls are performed:

- check of welds and their surrounding area on cylindrical part of reactor pressure vessel
- adheresion of cladding
- check of nozzles
- check of the vessel bottom
- visual inspection of reactor pressure vessel surface (cylindrical part, nozzles, ...)

b) Whole testing system together with manipulator is assembled on auxiliary bridge outside of reactor pressure vessel shaft area

c) After the reactor pressure vessel is prepared for inspection the assembled system is shifted over the reactor pressure vessel using fuel loading machine rails. Pillars are put into manipulator. After their centralization they will be rested on reactor pressure vessel bottom.

d) The inspection is performed under water level; construction of the manipulator corresponds to this requirment

e) Check of reactor pressure vessel is accomplished by various supersonic systems in accordance with agreed specification. It is possible to combine more than one check to be performed simultaneously that shortens time of inspection duration

f) Data obtained at measuring are transferred into processing and evaluation center via optical cable. Distance between the reactor and processing center is approximately 150 meters

g) Re-arrangment of system on manipulator is performed only after primary data verification

h) Measurement reliability is checked regularly in defined time intervals that prevent from generation and entering constant error into measured data

i) It is necessary that service personnel on each working place is 100% concentrated

3) Final phase of inspection

a) The final phase begins after accomplishment of entire inspection scope and verification of obtained data

b) Dis-assembling the manipulator and testing system and their final protocolar verification (whether parameters were not changed) is made during this phase

c) Evaluation of measured data continues using evaluating system

d) Results of inspection are compared with results of previous inspection

e) Regarding to fact that reactor pressure vessel surface is active it is necessary to perform decontamination of all used equipment

Transport

ZMM-5 manipulator is packaged in two containers (20 ft and 40 ft). Small pieces are packed in 20 ft container, the larger pieces of the manipulator are located in 40 ft container.

In case of inspection is performing outside of Slovak Republic territory it is necessary to realize transport at severe conditions according to agreement ADR 7. Auxiliary bridge is an integral part of ZMM-5 manipulator. Regarding to dimensions of the auxiliary bridge it is transported like a large freight and corresponding measures are applied of such a transport.

References

a) Personnel training - in 1992 - ZMM-5 manipulator
- TIMLOK system

in 1995 - SIALOK system

in 1996 - SAPHIR system
- SIMACON 5 control mechanism

b) Already realized inspections using ZMM-5 manipulator
- in 1992-1997 - there were performed 8 inspections in EBO nuclear power plant
- in 1995-1996 - there were realized 2 inspections in PAKS nuclear power plant