



METHODS, MEANS AND RESULTS FROM CONFINEMENT LEAKAGE DECREASE IN UNIT 2 AT KOZLODUY NPP

E. Demireva, Eng., D. Grigorov, Eng., Dr. E. Balabanov - ENERGORPOEKT plc

The design concept of units 1-4 confinement at Kozloduy NPP does not comply to the state-of-the-art requirements contained in the standards for confinements in Western European nuclear power plants. Naturally, these requirements are stricter than those used in the design of these units, thus making their direct application impossible. Kozloduy NPP reconstruction and upgrading, based on WANO's 6-month program, are aimed at finding a reasonable balance between the current safety requirements and the possibility to implement concrete technical solutions for confinement design improvement.

Within the framework of Theme D "Confinement Qualification" of the 6-month program, a long-term program to improve unit's 2 confinement characteristics was started with plans to transfer the experience and results to the other units with VVER-440 reactors as well. Work on this theme was a joint effort of engineers from Empresarios Agropados (EA), Spain and Energoproekt plc in close collaboration with staff from the reactor department of units 1-4 at Kozloduy NPP.

The following objectives were identified:

- Performance of experimental studies in order to assess confinement tightness (Local tests);
- Identification of ways and means to improve tightness;
- Performance of the most urgent repair works;
- Development of Global tests Procedures :
 - * Leaktightness Tests
 - * Structural resistance Tests
 - * Flap Reliability Tests

In order to meet these objectives a method comprising Local and Global tests was developed.

A. LOCAL TESTS

I. COLLECTION AND SYNTHESIS OF INFORMATION ABOUT LEAKAGE PATHS IN CONFINEMENT

The potential leakage paths in confinement are all equipment which crosses the boundary or is by themselves boundary of the confinement, irrespective of their design and functions. They are classified in 9 groups, common for all four units, the only difference being the number of isolating valves of the suction air ducts to unit's and 4 ventilation systems B-2 and B-4.

The elements (potential leakage path) of all 9 groups for unit 2 are done below:

Group 1 Heat, Ventilation and Air Conditioner(HVAC) Elements: These, in turn, are grouped into 5 sections:

1.1.	Cut-off Valves	28 units
1.2.	Pressure Relief Valves	30 units
1.3.	System B-4 Swing Check Valves	1 unit
1.4.	System P-2 and B-2: Swing Check Valves	2 units
1.5.	System P-1 HVAC shafts	5 units

Group 2 Doors and Suction Holes

2.1	Doors (total number considered)	12 units
2.2.	Suction Holes (in System B-3)	10 units

Group 3 Hatches and Manholes

3.1	System P-1 Hatches	15 units
3.2	System P-1 Manholes	6 units
3.3	Steam Generator Hatches	6 units
3.4	Main Coolant Pump Hatches	6 units
3.5	Main Isolation Valve Hatches	2 units
3.6	Primary Water Purification System Hatches	7 units
3.7	Reactor Vessel Cover (Dome)	1 unit
3.8	Maintenance Hatch	1 unit
3.9	Gate between upper part of reactor shaft and transport corridor to the spent fuel pool	1 unit

Group 4 Venting Flaps

4.1.	Flap valve with diameter 520 mm	1
4.2.	Flap valves with diameter 1130 mm	8

Group 5 Pipe Penetrations

5.1.	Used pipe penetrations	136
5.2.	Reserve pipe penetrations	59

Group 6 Valve Stem Extensions

Total number: 131 units.

Group 7 Electrical Penetrations

7.1.	type II with 8 penetrations	23
7.2.	type III with 16 penetrations	21
7.3.	type V with 4 penetrations	7

TOTAL: 51

Group 8 Sump Drain Valves

The 6 units are located in the following rooms: A102, A004/3, A004/4, A010/A011, A013, B007(A012).

Group 9. Liner

The walls, floors and ceilings of the confinement rooms are lined by stainless steel sheets. The total length of the liner welds is approximately 12 km.

II. PERFORMANCE OF LOCAL TESTSII.

1 Test Methods and Procedures

Two methods - quantitative and qualitative - have been used in the Local tests. For the purposes of applying them in tests of the individual penetration groups, Empresarios Agropados developed procedures stating the range of procedure application, test equipment, how to use the equipment, personnel qualification, instrument's calibration and the form of test result registration.

• QUANTITATIVE METHODS - WITH MEASURING

⇒ Pressure Decay

82D-AT-Q-1002 REV.1: Pressure Decay Leakage Test Procedure. This document describes the methods used to determine penetration leak flow through pressure drop measurement. It applies mainly to the HVAC valves located in ducts, May, 1992.

⇒ Flowrate Measurement

82D-AT-Q-1003 REV.1: Flow rate leakage Test Procedure. This document describes the techniques used to determine leak flow by direct measurement. It also applies to HVAC valves with an isolation function, May, 1992.

These Methods and Procedures are used for the "active" groups of penetrations [1].

- **QUALITATIVE METHODS - DETECTION**

- ⇒ Vacuum Box

82D-AT-Q-1001 REV.1: Vacuum Box Leak Test Procedure. This procedure describes the method of testing welds and flat surfaces of the liner, May, 1992.

- ⇒ Ultrasonic detector

82D-AT-Q-1004 REV.1: Local Test Procedures Scope of Tests and Selection of Test Method. This procedure describes the different methods for detecting and evaluating the possible leak points in the penetrations of confinement, and defining the criteria to choose the pertinent method in every case ., July, 1992.

- ⇒ Blueling

82D-AT-Q-1004 REV.1: Local Test Procedures Scope of Tests and Selection of Test Method. This procedure describes the different methods for detecting and evaluating the possible leak points in the penetrations of confinement, and defining the criteria to choose the pertinent method in every case ., July, 1992.

- ⇒ Water Leak

82D-AT-Q-1004 REV.1: Local Test Procedures Scope of Tests and Selection of Test Method. This procedure describes the different methods for detecting and evaluating the possible leak points in the penetrations of confinement, and defining the criteria to choose the pertinent method in every case ., July, 1992.

- ⇒ Visual Inspection

82D-AT-Q-1004 REV.1: Local Test Procedures Scope of Tests and Selection of Test Method. This procedure describes the different methods for detecting and evaluating the possible leak points in the penetrations of confinement, and defining the criteria to choose the pertinent method in every case ., July, 1992.

These Methods and Procedures are used for the "passive" groups of penetrations and for material surface qualification [1] .

From tests of each group of penetrations a representative sample is made, considering which conclusions for the state of the whole group are drawn. From the tests of unit 2 at Kozloduy NPP such a sample was prepared for the electrical cable and the rod penetrations. All other groups, except for the pipe penetrations, whose testing was impossible, were 100% tested.

II.2. Test Results Form

Test results and measurements are entered special forms. A special columns show whether the measurement has been approved or repair of the tested item of equipment with prior tests and approval is planned.

In cases when sufficient amount of statistical information about the individual groups of penetrations has been gathered, repair permits without advance measurements can be also issued.

II.3. Results from Local Tests of unit 2

Penetration	Tested components, pcs	Method	Result
GROUP 1 - Penetrations for ventilation systems			
Cut-off valve system B-2	26/28	Flowrate leakage test	No leakage after repair
Pressure relief valve of system B-4	30/30	Pressure decay leakage tes	Leakage after repair
Swing check valve system B-4	1/1	UT	Leakage
Swing check valve system R-2	0/1	-	Unaccessible for measuring
Fan shafts system R-1	5/5	UT	No leakage after gland packing renewed

GROUP 2 - Doors and ventilation holes between doors			
Doors	12/13	UT + Blueling	No leakage after rubber seals replacement
Holes of B-3	0/10	-	Open system

GROUP 3 - Hermetic manholes			
Round manholes of R-1	6/6	UT	No leakage
Manholes	37/37	Water	No leakage after repair

GROUP 4 - Venting Flaps			
Venting Flaps	9/9	UT	No leakage

GROUP 5 - Pipe penetrations			
Pipe penetrations	0/131	-	Structure allows no testing

GROUP 6 - Valve stem extension			
Valve stem extension	25/131	Pressure decay leak test	No leakage after repair

GROUP 7 - Electrical cable penetrations			
Electrical cable penetrations	39/51 panels	UT	Sealed, no leakage

GROUP 8 - Drainage penetrations			
Sump drain valves	6/6	Water	No leakage

GROUP 9 - Liner			
Sheets	1-15%	Vacuum box	18% abnormalities
Welds	1-15%	Vacuum box	3% abnormalities**
Cladding	100	Visual inspection	42 remarks

Note: **Leakage from spent fuel pool. Holes without sealing Traces from oxidation
Local test results show the necessity of tests and repair during each refuelling cycle.

III. WAYS AND MEANS TO IMPROVE CONFINEMENT TIGHTNESS

Qualification of unit's 2 confinement showed that the ventilation system, penetrations are the major source of leakage to be expected because of their great number - more than 60 penetrations with size above 250 mm. Just for comparison, the designs of Western nuclear power plants impose a limitation of two 200 mm penetrations during normal

operation. The isolating valves at the confinement boundary close up to 50% by gravity, and for the remaining 50% by electric drives with 30-60 s closing time. Isolating valves in the Western nuclear power plants are of the disk type with closing time 5 s.

One of the ways to upgrade confinement characteristic is to reconstruct and modify its ventilation systems. In /1/ are proposed the following modifications:

Repair/Modification Orders	Activities
	Ventilation system B-2
RMO-09	Reducing the number of suction valves from 14 to 9, and of the inflow valves from 14 to 11
RMO-11	Replacing the isolating valve dia 500 in suction air duct of B-2
	Ventilation systems П-4 and B-4
RMO-02	Reducing the number of excess pressure valves, dia 500 from 30 to 6
RMO-06	Installing a back-up disk valve in suction air duct of B-4 or replacing the present one
RMO-08	Making possible a local test of valve of RMO-06
RMO-117	Changing the type of drive of excess pressure valves dia 500, or replacing with better-quality valves
	Ventilation system B-3
RMO-08	Installing isolating valves, or removing the connections
	Ventilation system R-1
RMO-43	Replacing the sealing of fans' shaft by such providing the required tightness during operation.

Other ways to improve tightness are the periodic inspections and repair of the other groups of penetrations.

Group	Means to improve tightness
Doors	Planimetering Replacement of sealing
Manholes	Planimetering Replacement of sealing
Pipe penetrations	Chamber for periodic inspection of penetrations
Flap valves	Applying Greifswald NPP's experience
Electrical cable penetrations	Licensing of product for sealing of all penetrations

Speaking generally of the means for penetration's tightness, it should be noted that there is no experience in materials choice. In this respect, the experience at Bohunice NPP will be very useful.

B. GLOBAL TESTS

Empresarios Agropados and Energoproekt have developed procedures for global tests, namely:

82D-AT-Q-1005, Rev.1: Procedure for Global Confinement Tightness Test at reduced pressure for Kozloduy NPP units 1 to 4 , November, 1992

- Depressurization Stage to Verify Liner Leaktightness
- Pressurization Stage - 1.25 bar (abs.)
- Reduced Instrumentation to control the Test

82D-AT-Q-1006, Rev.1: Procedure for Global Confinement Tightness Test at nominal pressure for Kozloduy NPP units 1 to 4 , November, 1992

- Pressurization Stage - 1.6bar (abs.)
- Complete Instrumentation for Temperature and Humidity Correction

82D-AT-Q-1007, Rev.1: Procedure for Global Confinement Structural Integrity Test For Kozloduy NPP units 1 to 4 , October, 1992

- Pressurization stage - 2.15 bar (abs.)
- Pressure increments in gradual steps
- Cracks inspection and follow-up in singular points
- Displacements measurements versus maximum values by calculation

82D-AT-Q-1008, Rev.1: Venting Flaps Test Procedure for Kozloduy NPP units 1 to 4 , October, 1992

- Leaktightness test during closure and normal plant operation
- Calibration test on the Counterweight and the Stem Guide System
- Operating test on the Complete Assembly
- Complemented by Detailed Structural Analyses

In December 1992, a tightness test at pressure 1.3 bar (absolute) was carried out in unit 2 at Kozloduy NPP. After removing the untightness, mainly in the electrical cable penetrations, an equivalent leakage diameter of 103 mm was registered.

Many of the proposals relating to Item D, made at the end of the 6-month program, have been implemented at part of the units and the test results are indicative of the necessity and significance of this activity.

It is noteworthy, that in view of the future plans to build a filter-type ventilation system, the high degree of confinement tightness is one of the crucial design requirements.

REFERENCES:

1. Final Report for ITEM D, October 1992. Document of Impresarios Agropados 82D-FD-1005.