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MOTOR OPERATED VALVES ENGINEERING AND TESTING

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1.0 Introduction.

Motor Operated Valves (MOV) are in many plant systems safety-related part of equipment. From their proper function depends response of a safety system and its essential function. Their proper maintenance and testing is an important part of every nuclear power plant surveillance and testing programs.

2.0 Regulatory requirements

The ASME Code Section XI stroke-timing test for MOVs is performed to meet the inservice testing requirements of 10 CFR 50.55 a (g). Section XI testing for MOVs consists of stroking Class 1, 2 and 3 valves, that means opening and closing the valves, usually without fluid pressure of flow in the lines and measuring stroke time. Performing this tests in connection with other system tests the plant personnel can verify MOV operability.

Generic Letter (GL) issued by the United States Nuclear Regulatory Commission (US NRC) recommends periodic verifications of the capabilities of MOV to perform their design basis functions This GL does not specify the type of verification testing to be performed, nor a specific interval between verification tests. Rather, an interval of four and one half years to six years in suggested, unless justification is provided for another interval. The main goal of each nuclear power plant should be to verify each MOV's continued preparedness to operate under the worst-case operating conditions postulated within the plant design basis (1).

3.0 Assessment of MOV performances.

The program to verify MOV switch settings should be extended in order to ensure operability of all safety-related fluid systems. The NRC's staff evaluation of the data indicates that, unless additional measures are taken, failure of safety-related MOVs will occur much more often than had previously been estimated.

The nuclear power industry has developed methods to determine the relative contributions each MOV makes toward safe plant operation and is being encouraged to use these methods. The NRC allows different safety significance to be the bases for different treatments of MOV's in GL 89-10 programs, and what is more important, utility personnel have the capability of determining the design margin of each MOV.

By combining relative safety significance and design margin information, the MOVs can be ranked according to their relative overall significance, that means, their relative potential to cause negative effects if they should fail to perform their design basis functions. In accordance with this approach, the group of MOVs, which has greater potential to cause negative effects should receive more attention in a maintenance and testing program.

4.0 Assurance of MOV operability.

Assurance of MOV operability is a complex task. It involves many factors such as development of strong testing and maintenance programs, management support and coordination of engineering, maintenance and testing.

All these effects should be viewed by all concerned as a long-term ongoing program. Specific training for personnel dealing with this program should be required.

As first step in this process, licensee must develop MOV diagnostic test system. On this base licensee should establish their needs for training of plant personnel. Training program should include following steps:

a) interaction of different MOV parameters on valve performance

b) which parameters and their changes, as a minimum should be monitored:

   - motor efficiency,
   - actuator gear train efficiency,
   - stem factor,
   - packing or torsion spring in the torque switch,
   - spring pack preload or stiffness,
   - torque switch balance,

c) adequate testing equipment function,

d) technical documentation review,

e) practical work with this type of equipment on a test stand,

f) verification and comparation of results (accuracy).

Actuator output torque of MOV is often a performance parameter of interest as could be concluded from nuclear industry reports and practice. One of the most common failures is improper torque switch setting. As the consequence, in the case of this improper setting the actuator motor will burn-out and the MOV will be inoperable.

Inoperability of MOV is important contributor to safety system failure and in last stage to core damage.

Well trained maintenance personnel will be able to proper set torque switches. It can be expected that this type of equipment will perform its function properly.

5.0 General guidance for developing MOV program.

MOV valve program design standard should include following sections:

- Valve Population Verification
- Operational Basis Calculation
- Degraded Voltage Calculation
- Weak Link Calculation
- Set Point Calculation
- Test Data Reconciliation
- Computer applications to efficiently handle calculations and data storage.

The causes of MOV failure could be mainly:

- Torque switch setting
- Stem binding
- Packing binding
- Motor failure
- MCC failure
- AC power failure.

6.0 A review of MOV performances.

US NRC department of Assessment and Evaluation of Operational Data (AEOD) has made a review of MOV performance (4).

Major licence's problems should be solved by following recommendations

- improve methods for torque switch setting,
- reliable signature tracing technique (measurements of current and voltage, which serve as an indicator of changes in operability and also as a predictor of the remaining margins of failure),
- guidance to by pass thermal overload protective devices of MOV should be reassessed.

In the case of undetected valve failure the MOV would be deemed operable based on a surveillance test, but actually would not operate during the next demand. There is a possibility that there are the failures that were not detected during testing. Most important conclusions issued by AEOD department were that currently used methods and procedures used for testing MOV in many plants were not adequate (3).

Measured parameters during testing MOV:

- axial displacement of the warm to compress the operator spring pack (this displacement is proportional to the thrust delivered to the valve stem, measured by thrust measuring device - load cell),

- time of actuation of torque and limit switches

- time dependent motor current.

Systems most affected by MOV inoperability are, for a typical PWR approximately as follows:

- Residual Heat Removal (PHR)/Containment Spray: 27,5%
- Essential Service Water (ESW): 15%
- High Pressure Safety Injection (HPSI): 11,6%
- Auxiliary Feed Water: 8,5%
- Main Steam (MS): 7,6%
- Reactor Coolant System (RCS): 6,9%.2

7.0 Relative Safety significance of MOV.

The relative safety significance of each MOV in certain system should be first determinated by a Probabilistic Risk Assessment (PRA). The MOVs are then ranked such that those MOVs with the greatest safety significance have highest factor of safety significance and those which the least safety significance have a minimal factor.

Then the minimum design margin (the minimum of the ratios of the differences between the calculated minimum loads required to ensure proper MOV operation and the maximum allowable loads which ensure structural and motor integrity divided by the respective maximum allowable loads) is also determined for each MOV.

The ranking of MOV by these two parameters was done in Comanche Peak Steam Electric Station (Texas, USA) in order to determine MOV relative overall significance. On these bases the utility should determine the maximum suggested testing interval for specific MOV (2).

For the near future, a less conservative and more realistic MOV safety significance analysis is planned in several nuclear power plants.

8.0 Conclusions.

In NPP Krško exists a systematic approach to establish a MOV testing and surveillance program. Determination of MOV groups that will be involved in this program is under process and based on PRA studies the safety significance of specific MOV's will be determined.

The measuring devices (testing equipment with data acquisition system) are provided and operating personnel was trained.

Compliance with the NRC recommendations, issued in GL89-10 and their supplements is not an easy task for any nuclear power plant.

There are still many challenges, which include a certain amount of uncertainty, as for example:

- MOV performance verification by testing installed valves at design basis conditions may not be possible or may result in valve damage,
- analytical methods commonly used for calculating the required stem load do not always yield accurate results,
- stem load obtained by measuring actuator spring pack deflection may contain significant uncertainty,
- test results for conditions less severe than the design basis conditions, linearly extrapolated, may not be sufficient to assure valve performance at design basis conditions,
- using previous MOVs testing results to completely characterize MOV performance,
- valve or actuator performance changes due to wear, aging or maintenance activities must be accounted for in assessing continued MOV switch setting adequacy.

Slovenian Nuclear Safety Administration is following all above mentioned activities and trends, ongoing activities on this field in NPP Krško and worldwide published reports about this nuclear technology field.

References:

1. US NRC Generic Letter No. 89-10: Safety Related Motor-Operated Valve Testing and Surveillance,
2. Program for Periodic Testing of MOVs per Generic Letter 89-10, Bill R. Black, Comanche Peak Steam Electric Station, TU Electric, Texas,
3. NRC Generic Letter No. 89-10, Supplement 5: Inaccuracy of Motor-Operated Valve Diagnostic Equipment,
4. A Review of MOV Performance, US NRC, AEOD C603