AREVA's Innovative Solutions for Valve Diagnostics and In-Situ Valve Repair

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Abstract

Optimized maintenance strategies are a key aspect for safe and undisturbed plant operation. Innovative valve service solutions can support that in an efficient way.

The ADAM®/SIPLUG® valve monitoring system allows full online monitoring of valves and actuators with automatic evaluation and assessment.
Especially for safety-related and operation-related valves this provides valuable information on components condition to ensure proper function and contribute to optimization of maintenance strategies as well as effective maintenance performance.
More than 25 years of experience in various plants worldwide show that application of ADAM®/SIPLUG® valve diagnostics solution leads to increased plant safety and availability.

With the innovative AVARIS technology an in-situ valve repair is possible. It has the unique ability to conduct several steps in-situ, to maintain the sealing seat of gate or check valves. By applying AVARIS, the valve is restored in its original state, the system remains unchanged. Thus, all original documents remain valid and applicable.
In comparison to previous procedures like cutting valves out of the pipeline and repairing hard facings or damaged seal seats in a separate workshop or alternatively replacement by a new valve body the new AVARIS technology avoids costs, risk and effort.

Introduction

Stable function of valves and their actuators as specified by design is essential for NPP operation meeting all safety and reliability requirements.
This goal implements optimized maintenance strategies that can be efficiently supported by dedicated valve services like innovative diagnostics or refurbishment solutions.
Main objective for using monitoring systems is the detection of changes in the functional behavior of valves and actuators without direct intervention (e.g. for visual inspection). This provides an important basis for the change to condition-based maintenance with full reference to valve design and specification. The ability to perform also refurbishment measures is part of the maintenance cycle. It is the final step in demand for maintenance and meets the requirements of the modern maintenance strategy.

Integrated Valve Services

Taking the different aspects and criteria for the specified function of valves and actuators into account, AREVA established an integral approach, see Figure 1.

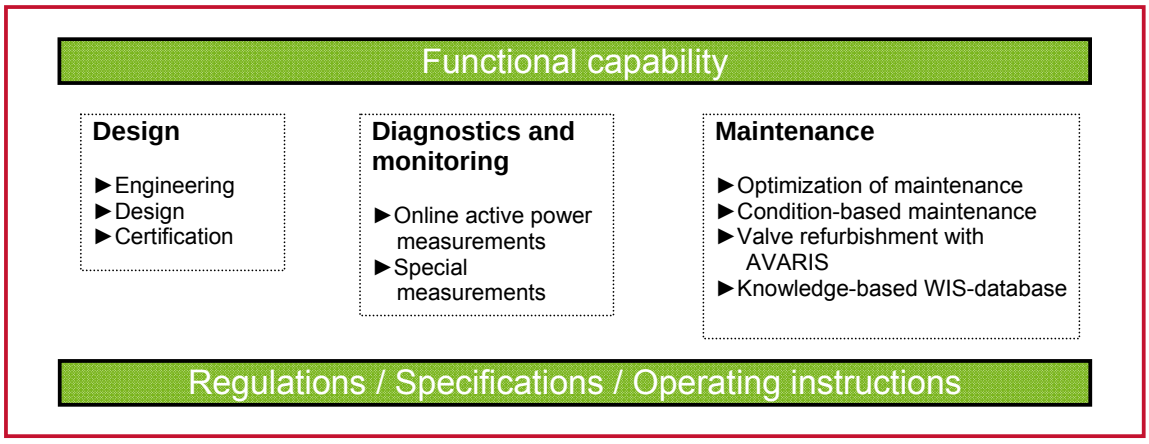

Figure 1 Integrated Valve Concept

This concept is based on our extensive know-how in valve and actuator technology and has already been successfully implemented in Germany and abroad.

There are three main fields
- Calculation / design
- Maintenance / repair
- Diagnosis and monitoring

which are the foundation for a steady and safe function of valves and actuators.

Related to these 3 main areas AREVA provides an integral scope of services:

- ► Valve technology and valve qualification
- ► Estimation of remaining service life time of valves
- ► Engineering support
- ► Valves and actuators diagnostic services with **ADAM® / SIPLUG®**
- ► Selective maintenance and repair measures with **AVARIS**

Valve and Actuator Diagnostics Overview

Within the integrated valve services the field of diagnosis and monitoring is getting more and more important.

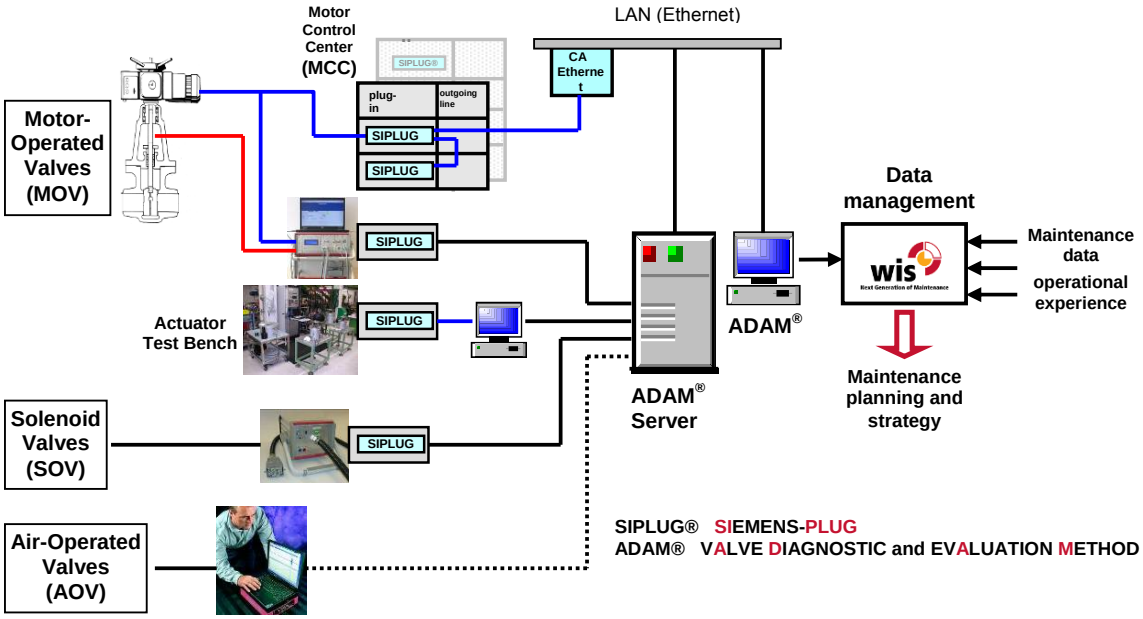

Figure 2 **ADAM® /** SIPLUG® valve and actuator diagnostics overview

Reasons and motivation for valve diagnostics and monitoring are:

- Verification of the functional behavior of valves and actuators at operating conditions and safety-related conditions
- Verification of appropriate safety margin of torque and force
- Timely initiation of measures for identified changes / irregularities
- Traceability of fault messages
- Increased plant availability

ADAM® / SIPLUG® Concept

AREVA covers the complete scope of products and services for state-of-the-art diagnosis on valves and actuators in nuclear power plants.

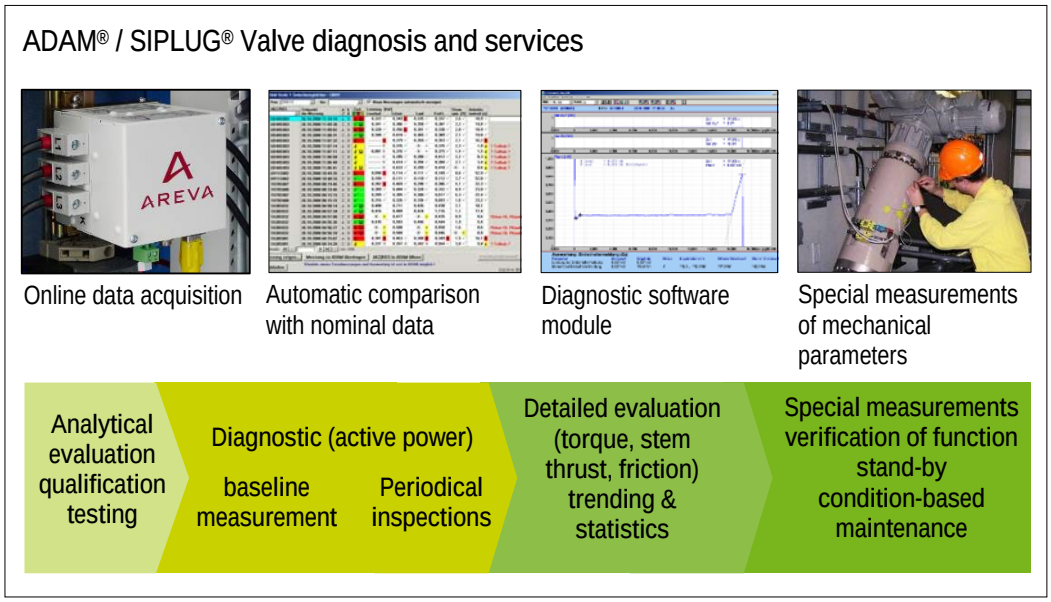

Figure 3 **ADAM® /** SIPLUG® Valve and actuator diagnostics concept

With SIPLUG® measurement equipment and ADAM® software AREVA has a modular valve diagnosis system.

SIPLUG® technology provides dedicated diagnostics solutions for different customer requirements. It is designed for data acquisition inside or outside the plug-in units of the switchgear of nuclear power plants. With SIPLUG® diagnosis modules the plant operator will be able to perform the assessment of electrical and mechanical characteristics of motor-operated valves and their electrical actuators through active power measurement.

Figure 4 SIPLUG® 4 modul

The new **SIPLUG®-4** modules (Figure 4) are the evolutionary solution for valve diagnosis at the Motor Control Center (MCC). As the **SIPLUG®-4** can be installed directly in the MCC outgoing actuator power cable it requires less engineering work and allows an easy installation in existing switchgear cabinets.

For the monitoring of solenoid valves another type of SIPLUG® is available which supports the assessment of the dynamic and electrical behavior of solenoid-operated valves by measurement of voltage and current.

SIPLUG® DAW3 allows parallel measuring and recording of electrical and mechanical data for the diagnosis of valves and actuators. Flexibility in use has taken priority in the design of the device; the integration of additional input channels represents a significant extension of functionality within the SIPLUG® series. In addition to acquisition of electrical signals there are four additional channels with integrated programmable preamplifiers, three for force or torque measurement and one channel designated to the displacement path / rotation angle.

The **ADAM®** evaluation software and database was developed in parallel with the hardware. It provides automatic analysis of the monitoring results using the limit values specified for the valves. The measured data can be transmitted via the power plant's local area network to the ADAM® data server, if the SIPLUG® online hardware is installed. With the mobile solution, the data can be transmitted via serial or USB interface to a PC or notebook. With this solution all measurement information will be available immediately in the offices of plant engineers.

With SIPLUG® online all operations of valves can be automatically recorded. Ring buffer always keeps the last valve operations in the SIPLUG® memory, even if power fails. Consequently, post-fault analyzing is possible, if some irregularity during valve movement is recorded.
Data are immediately available for further analysis / evaluation. The system provides fully automated evaluation (Figure 5) of each valve operation with flag status results. This provides a full overview on valve status at any time.
Measurement at MCC means a zero effort for performance of diagnostics reducing the number of on-site activities. This results in decrease of maintenance costs and dose rates for deployed personnel.

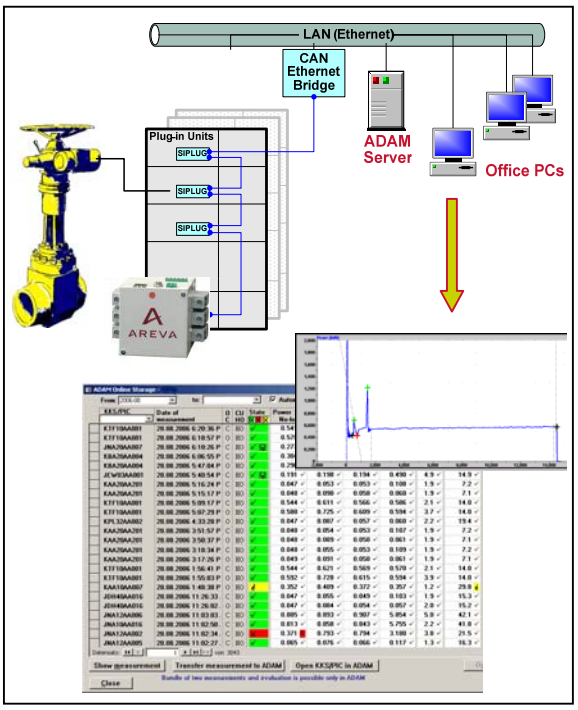

Figure 5 SIPLUG® online with automated evaluation

Valve Diagnostics Services

Combining the features of these valve monitoring tools and equipment with expert knowledge and experience in valves and actuators design, function and maintenance we also provide a full range of related service activities to support plants in all stages of valve diagnosis (cf. Figure 3):

- ► Performance of active power measurements of the actuator (in-situ, from switchboard or online)
- ► Performance of baseline measurements of actuators during valve maintenance and establishment of correlation between active power and torque
- ► Additional direct measurements of mechanical parameters (e.g. torque, thrust)
- ► Evaluation and assessment of measurements and comparison with nominal values and allowable limits
- ► Determination of changes in the function of valves and actuators during their lifetime
- ► Root cause analysis and/or discussions with experts and authorities of an accredited inspection body
- ► Provision of recommendations (> condition-based maintenance)

Testing of electrical actuators

Efficient and precise testing and adjustment of actuators, e.g. at the end of maintenance activities, is an important basis for future valve diagnostics via active power measurements without disassembling of the actuator.
Early diagnostics of faulty operation of a valve can be done by determining the torques of the valve actuator on a regular basis.

For testing and adjustment of electric actuators AREVA developed mobile actuator test devices **(MDP**), see Figure 6.

- ► The MDP consists essentially of an electromagnetic brake. It is available in different sizes for actuators in the torque range of 10 to 3.500 Nm
- ► The MDP ensures a precise increase and decrease of the actuator braking torque for simulation of built-in conditions on the valve
- ► The MDP control device is embedded in **ADAM®** using torque gradient requirements and for recording, processing and storage of data in **ADAM®**
- ► Possibilities: Loop-in operation of the actuator or operation with autonomous control unit

Implementation of the torque / active power correlation in **ADAM®** provides the basis for evaluation of mechanical valve behavior from active power measurement during operation.

Figure 6 MDP family with control unit and data acquisition

Figure 7 ADAM® system with MDP test benches and control panel in a workshop

References

Especially for safety and availability related valves steady function according specification and design is essential for safe and reliable plant operation.
Valve monitoring and diagnosis provides important information on the condition and functional behavior of valves and actuators and, therefore, supports the way to condition-based maintenance.

AREVA has more than 25 years international experience in valve & actuator diagnostics, e.g. in Germany, Switzerland, Brazil, Spain and Eastern Europe.

In different nuclear power plants safety-related and operation-related valves are monitored continuously:

- PWR 1 600 MOV equipped with SIPLUG® online
  about 70,000 valve operations per year recorded and automatically evaluated via ADAM® software
- PWR 2 1,000 MOV monitored with SIPLUG®
  120 SOV with SIPLUG® MAG
- BWR 1 550 MOV monitored with SIPLUG®

In addition specific in-situ valve diagnostics (active power, force, torque) were performed in various nuclear power plants.

AREVA provides a complete scope of products and services for state-of-the-art diagnosis on valves and actuators in nuclear power plants. With longtime experience and know-how we support plants in all stages of valve diagnostics considering specific valve design / engineering aspects as well as maintenance requirements.

Besides diagnosis and monitoring, the refurbishment measures take an increasingly important part inside the maintenance cycle. One of these tools is AVARIS. This is a method which allows refurbishing the seat of gate or check valves so that it will be as good as new.

AVARIS – AREVA VALVE REPAIR IN-SITU

AVARIS procedure has the unique ability to conduct several steps in-situ, to maintain the sealing seat of gate and check valves. The main processes are:

- Disassembly of the valve with general inspection
- Initial assessment and analysis also with digital 3D measurement to adapt machining sequence on geometrical deviations of valve bodies
- Turning down of worn or damaged seal seats
- Overlay welding of the new hard facings and
- Finish turning and grinding of the sealing surface to the required quality
- Replacement of the wear parts and reassembly of the valves

By applying AVARIS, the valve is restored in its original state, the system remains unchanged. Thus, all original documents remain valid and applicable.

Background and Challenge

Gate and check valves are commonly used to open and close pipe systems in a wide range in power plants. A spindle in the gate valve or the return flow forces plates to seal against the seal seats within the valve body (see Figure 8).

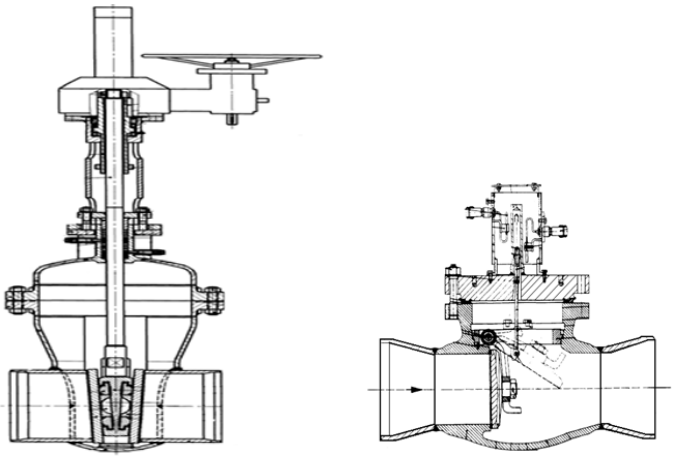

Figure 8 Gate valve and check valve

These seal seat surfaces degrade as they are worn down over many cycles of use during the valve's service life.

Figure 9 depicts the damage and wear symptoms which can be found over the years:

- (a) Scoring due to insufficient hardness or a thinned hard facing of the seal seat
- (b) Cracking due to stress and strain
- (c) Breakout or complete wear-through of the hard facing seal seat layer

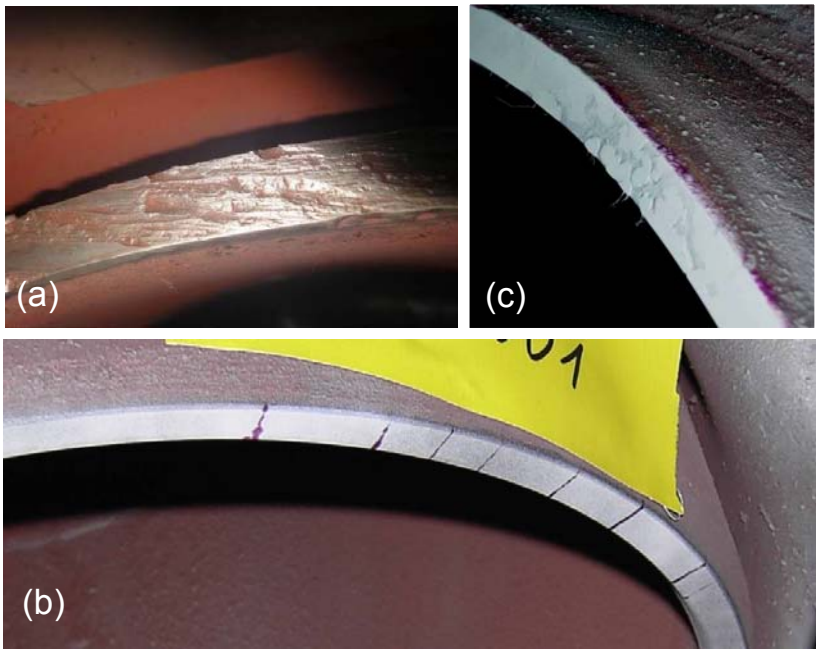

Figure 9 Damage and wear symptoms at seal seats

Conventionally, worn seal seats of installed valves are ground during outages. This results in a reduced thickness and hardness of hard facing layer. Since thinner hard facing layers tend to wear down faster, the probability of component failure increases.

Up until now, valve bodies with thinned hard facings or damaged seal seats had to be cut out of the pipeline system and fixed in a separate workshop or alternatively replaced by a new valve body. Both options cause a lot of cost, risk and effort. Furthermore, in many cases the concerned valves are not manufactured any more, which makes a delivery of new valve bodies almost impossible.

AVARIS – AREVA's solution

To meet the customers' demand, AREVA has developed AVARIS – a concept to refurbish installed valves by in-situ turning and welding operations on the seal seats. The major objectives of the AVARIS maintenance services are:

- Restoring the original geometry as well as reaching the specified hardness of e.g. 340-400HB
- Sealing function and life expectancy of a refurbished valve equivalent to those of a new valve

Principal components of the AVARIS technology are a mobile turning machine and a welding machine which can be deployed to operate in tight spaces within the pipeline system. According to the schematic diagrams (see Figure 10) an inner clamping unit is inserted into the pipe end opposite to the actually machined seal seat. This clamping unit represents an interface to the welding and turning model.

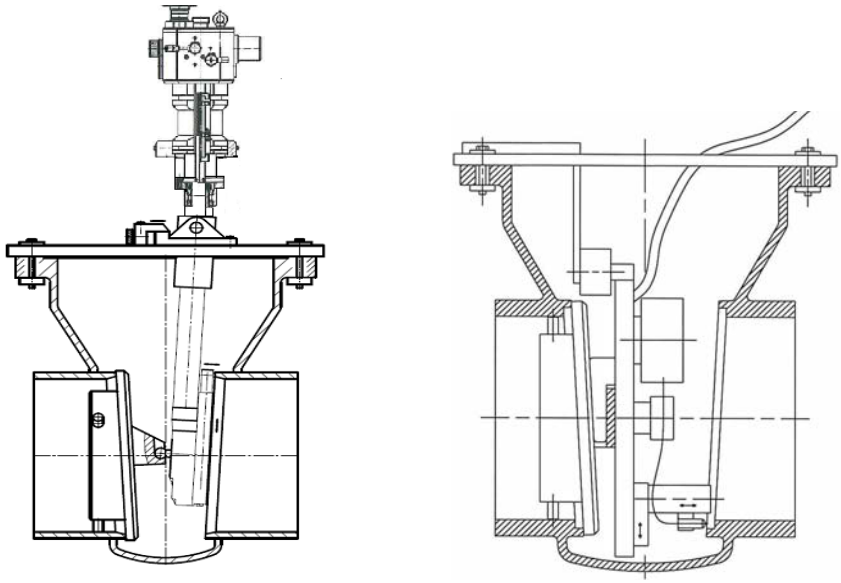

Figure 10 AVARIS turning and welding solution

The turning machine concept is characterized by:

- Customized equipment to the customer's needs
- DN 80 (3") to 800 (32")
- Competence to cut off the old damaged hard facing as well as to perform finish turning operations
- Adjustability on specified wedge angles of seal seats
- Clamping on valve flange or inner clamping unit

The welding machine concept is characterized by:

- A mechanized orbital TIG (Tungsten Inert Gas) welding module
- A welding diameter range from 80 to 800 mm
- Adjustability on specified wedge angles of seal seats
- Mounting on inner clamping unit or on the valve flange

Experiences during AVARIS applications

In June/July 2010, an AVARIS team of specialists from AREVA applied the technology for the first time. In a German nuclear power plant two valves were successfully refurbished. The technical parameters of the valves are:

- DN 500mm; PN 25bar, main condensate piping system
- DN 700mm; PN 16bar; main feed water piping system

Since this time, there have been a lot of applications of AVARIS in nuclear power plants in Germany and France where valves with different diameter were refurbished successfully.

Advantages for the plant operator

AVARIS is a unique technology that substitutes the existing practice of a complete valve body replacement. This applies especially when the manufacturer of the valves no longer exists. Furthermore, AVARIS provides significant advantages to customers such as time and cost savings in the planning and realization phase. If the valve needs to be replaced, the planning time may take up to two years e.g. for new construction, licensing, pressure tests of the new valve and meeting of documentation requirements. In contrast, AVARIS facilitates short term preparation since no valve design modification is realized. The application of AVARIS takes only one week compared to up to three weeks for the realization of a replacement.

Summary

Valve maintenance covers a wide field of activities, tools and technologies. Based on the current development of maintenance strategies, diagnosis and monitoring will have more influence in the daily business and become an important part in the maintenance cycle. The utilization of the diagnosis and monitoring results has a direct impact to find the right maintenance strategy. The realization of the recommendations saves costs and improves the resources management very effectively.

The AVARIS technology opens up new ways to refurbish installed valves by in-situ turning and welding operations on seal seats. This method completes the capabilities of the maintenance cycle.