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Your letter of	Market Research No.52026
Our reference	F.039857-B-00
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**Budgetary Quotation
No. F.039857-B-00**

of

Framatome GmbH

to

Kozloduy NPP EAD

on

Software program (system) for optimization of activities on aging management of the thermo-mechanical equipment in Turbine Department

Framatome GmbH

Framatome

Kozloduy

André Zander   Christoph Kurlbaum

1. Introduction

With regard to Market Consultation No. 52026 and Terms of Reference (TOR) No. 23.EP-2.TZ.1252 request for budgetary proposal, Framatome GmbH is pleased to provide a budgetary estimate to Kozloduy NPP EAD on

'Software program (system) for optimization of activities on aging management of the thermo-mechanical equipment in Turbine Department'

The software application offered is the COMSY program, which has been developed by Framatome to provide an effective software tool for the plant life management of systems and mechanical components. The COMSY software based on Windows™ utilizes experience resulting from research activities and operational experiences. It is designed to support a plant-wide strategy providing lifetime predictions for mechanical electrical and structural components, thus supporting plant life extension activities in respect to the aging surveillance program. The objective is to establish economically optimized maintenance and inspection programs, while maintaining high levels of plant safety and availability.

The tool provides the capability to establish a program guided technical documentation of the plant. The software integrates engineering analysis functions and comprehensive material libraries to perform a lifetime analysis for various degradation mechanisms typically experienced in power plants (e.g. flow-accelerated corrosion, cavitation erosion, flashing, droplet impingement erosion, material fatigue, strain-induced cracking) and degradation sensitivity assessment (e.g. intergranular stress corrosion cracking, pitting, MIC, etc.). A systematic prioritization methodology serves to focus inspection activities on degradation relevant locations, where a degradation potential exists. An integrated inspection management module serves to provide feedback from the existing examination results in order to further optimize inspection locations and scope. For this purpose, trending functions support the comparison of the as-measured condition (e.g. with NDT techniques) with the predicted progress of degradation while including allowance for measurement tolerances. The results of this comparison are used to improve the accuracy of future life expectancy predictions. On the basis of these predictions, inspection and maintenance management can be optimized.

2. Requirements and conditions for implementation, specified in the Terms of References

2.1 Scope of the software

Framatome offers to deliver a software program for the assessment of the material degradation effects: erosion/corrosion (EC) including cavitation, flashing, and droplet impingement as well as flow-accelerated corrosion (FAC). Based on the input data, it provides prognosis of e.g. metal wear in a selected section and predicts points of critical thickness of the base metal or weld material of respective components including small bore piping. On this basis the in-service inspections and repair of technological equipment can be optimized.

The scope meets the specification in chapter 1 and 2 of TOR No. 23.EP-2.TZ.1252.

Next to the software product, Framatome offers to provide training and software service support.

If desired, the optional Module M3 (fatigue) is also stated in this offer.

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2.1.1 General requirements

The COMSY software product is operated under the management of the operating system MS Windows

32 bit or 64 bit (Windows 10, 11 and following), it is compatible with the Windows Active Directory network architecture of the local administration system.

COMSY is a multi-user system, which allows for networking with the product. The data is securely stored in a single database server, and reviewed and edited by multiple workstations located in the local network. The COMSY data storage platform is MS SQL Server or optionally a MS-Access compatible database. The access to read and modify data is separated into user-groups. Depending on the database type, it has a module for administration of access to different groups. It keeps information of the user and the date of data correction in a log-file.

The COMSY product allows for import of data from text, Microsoft Excel or other Microsoft Office files. It also allows for the export of previously entered data in the same formats.

2.1.2 Specific requirements

The COMSY software contains:

- Geometric data and characteristics of vessels and pipelines - data is entered by a graphical interface giving the user a clear idea of which segment data is processed.

- The plant database includes: water chemistry parameters, thermal hydraulic operation parameters, design parameters, measurements of thickness, date of commissioning, period of days of effective operation time.

- Library of design data (according to GOST, DIN, KTA, ASME, etc. – also covering VVER-units), required to perform the computations of the analytical part of the program.

- Library of the standard material data (according to GOST, DIN, KTA, ASME, etc.).

- Library of measured alloy content material data (e.g. Cr content measurements, etc.)

- Structural and installation dimensions of the elements

- Specification of links and upload of files to each element, with an option to view the attached files. As a minimum, it supports file formats in AutoCAD, Microsoft Office, Microsoft Visio, PDF, text files, etc.

- User interface is developed for easy and convenient data entry manually and also from a file for specific import functions (e.g. MS Office). It carries out checks for completeness and integrity of data and shows clear messages to the user in case of error, with tips for necessary actions.

- Storing and assessing of NDT measuring data and calibration of the calculated predictions

The analytical part, based on the database, performs calculations and gives prognoses for:

- Emergence of a certain corrosion type in an equipment section – corrosion-erosion, cavitation erosion, flashing, droplet impingement erosion and their synergy effects

- Thinning of the metal wall for single and two-phase flows, depending on: period of operation, water chemistry mode, geometry of the respective item (elbows, T-branches, reducers, straight pipes, etc.) and the material it is made of, flow velocity and fluid mode (bubble, pulsating, stratified, wavy or annular flow), local pH and oxygen concentrations and if available measured alloy contents (Cr,

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Mo, Cu). In general, to model operation parameter and chemical composition of the water for different operation conditions from the history of the plant.

- Based on the predicted evolution of degradation, vulnerable (critical) elements are identified and a deadline for their inspection is set.

- As a result of wall thickness data entries, single 3D graphic diagrams and model of vessels and piping elements can be visualized by a color diagram according to calculations made for corrosion and thinning with an option to print and export to a file (jpg, gif, bmp, etc.).

2.2 Organization of work

Framatome owns the Software and provides a license / document for rights to use and origin of the computer codes (see Chapter 3.1).

Framatome will submit to Kozloduy a guide for installation and setup (description of the configuration files, system requirements, etc.), a detailed software user manual, installation packages and documentation of the program (see Chapter 3.1.2).

Framatome will provide training for the software (see Chapter 3.2.1).

The resulting version of the system shall be installed at NPP, Kozloduy premises jointly by a team of Framatome and Kozloduy for functionality validation. Validation is performed at NPP, Kozloduy side premises according to a test plan for validation prepared in advance by Framatome.

Framatome will submit the product according to the desired time schedule (see Chapter 5).

3. Scope of supplies and services of Framatome

Based on Kozloduy tender technical specification TOR No. 23.EP-2.TZ.1252, the following software package including several software modules will be offered to Kozloduy:

3.1 COMSY Software Tool for Erosion/Corrosion (EC) prediction and monitoring

The corrosion monitoring and prognosis software tool COMSY integrates engineering analysis functions and comprehensive material libraries to perform a lifetime analysis for corrosion related degradation mechanisms typically experienced in power plants. Those are: flow-accelerated corrosion (FAC), cavitation erosion, flashing, droplet impingement erosion (and their synergy effects).

A systematic prioritization methodology serves to focus inspection activities on degradation relevant locations. An integrated inspection management module serves to provide feedback from the existing examination results in order to further optimize inspection locations and scope. For this purpose, trending functions support the comparison of the as-measured condition with the predicted progress of degradation while making allowance for measurement tolerances. The results of this comparison are used to improve the accuracy of future life expectancy predictions.

The COMSY software handles a large number of parameters affecting the degradation process, e.g. mass flow, velocity, temperature, steam quality, piping geometry, water chemistry parameters such as oxygen concentration and pH, material composition etc. The predictive model computes degradation rates and provides data on minimum residual life expectancy for individual piping elements and vessels. The application of sophisticated calculation functions related to the progress of component degradation presumes a number of known parameters. As many of the system parameters required for lifetime prediction cannot be obtained from system documentation, various engineering tools for data pre-processing are integrated with the COMSY application scope.

The functionality included covers water chemistry cycle calculation, stress computation functions, steam table, stability calculations, thermal hydraulic and flow calculation functions. A standard material library serves as a knowledge base for material properties.

Based on lifetime predictions an inspection deadline is proposed for each individual piping element. The program system handles the storage, administration and documentation of examination results. Examination results are used for further lifetime prediction with increased prediction accuracy (trending).

3.1.1 COMSY- Software Modules for the requested scope by the tender

The scope of COMSY functions related to Erosion/Corrosion (EC) prediction covers the following modules (for more detailed information about complete software family please refer to the product information in the appendix):

Module G1: COMSY user interface and basic platform for plant modeling

The software product COMSY is operated under Windows®. The software system acquires, manages and evaluates design and operating parameters relevant to service life. Plant data pertaining to individual vessel elements, piping elements and systems are stored in a "virtual plant data model". This module includes a user platform in a local or network application, data management for safety requirements, engineering tools, material library, integrated schedule tables etc. For further details, please refer to Appendix, module G1.

Module G3: Integrated technical documentation management

The integrated technical documentation management function provides the option to interactively associate detailed documents, such as design drawings, P&IDs, reports from the time of plant construction or change procedures as well as memoranda. For further details, please refer to Appendix 1, module G3.

Module M1: Plant-wide sensitivity analysis and water chemistry cycle calculation

The COMSY water chemistry cycle calculation function serves to supply system-related water chemistry conditions for flow-induced corrosion analysis at any cycle location modeled. It consists of a graphical user interface, a plant database and a code for computing chemical properties in a water/steam cycle. COMSY is capable to calculate the distribution of oxygen and / or up to 9 alkalizing agents used in the secondary cycle (e.g. ammonia, morpholine, ETA etc.). For further details, please refer to Appendix 1, module M1.

Module M2: Degradation prediction models and evaluation functions for flow-induced corrosion mechanisms (FIC)

The COMSY flow-induced corrosion analysis functions serve to perform weak point analysis and lifetime prediction for power plant piping systems. The lifetime prediction functions allow to focusing inspection activities on elements most susceptible to flow-induced corrosion.

Owing to the approaches built into the program the results of the predictive computations are conservative. Their accuracy is governed by the tolerance bandwidth of the input data. The calculation of wall thinning rates utilizes the given modeling structure for piping as described for module M1 and M2) in combination with inspection experience feedback, as described for module M7). For further details, please refer to Appendix 1, module M2.

Module M3 (Optional): Degradation prediction models for material fatigue and associated load cycle data management

COMSY utilizes formulations according to TRD301, ADS2, KTA3211.2, and ASME Sec.III to determine the fatigue sensitivity of piping components. For each element the allowable number of cold starts is computed. If a specification regarding the load cycles actually experienced exists, the usage factor and the respective remaining fatigue life can be computed. For further details, please refer to Appendix 1, module M3.

Module M6:   Risk informed prioritization and inspection planning

The integrated risk informed prioritization function manages risk-related parameters and assesses the likelihood of occurrence of degradation mechanisms based on the given degradation models. It supports RI-methodology related functions including visualization. The integrated ranking function serves to focus inspection activities on safety relevant elements with an existing degradation potential. The computer guided ISI selection procedure supports the generation of an ISI schedule and the selection of appropriate inspection techniques for the respective item. In addition, it allows for engineering judgment interactions. For further details, please refer to Appendix 1, module M6.

Module M7:   Examination data management

This module handles the storage, administration, evaluation and documentation of NDT examination results. Examination data are utilized for further lifetime predictions with increased prediction accuracy. This module provides long-term management capabilities for large amounts of wall thickness readings performed on power plant piping. This module includes the management of inspection and maintenance procedures. For further details, please refer to Appendix 1, module M7.

3.1.2   COMSY – Software License

The COMSY-software application packages for Kozloduy comprise:

- Timely unlimited COMSY software licenses depending on purchase order, including the modules for the desired application (Software components G1, G3, M1, M2, (M3 optional), M6 and M7)

- The User Interface will be supplied as a ready-to-use program version of COMSY (version 3.18 or higher) with a user interface in English and Bulgarian language. There is no time limit on code application.

- Two (2) COMSY User Manuals (Operation and Maintenance Manual in the original language, 1 pc in English and 1 pc in Bulgarian language), a guide for installation and setup (description of the configuration files, system requirements, etc.)

- Software license keys covering a total of 10 plant users, see chapter 3.1.4

3.1.3   Industrial workstation

The workstation will contain 1 installed Operating System, the COMSY Software license and a default COMSY Microsoft Access database or local SQL Server database for demonstration.

The workstation will not contain the final productive Microsoft SQL Server database, which is in responsibility of the IT department of Kozloduy. Framatome will furthermore deliver a default COMSY SQL Server database to be used as productive database for network application to the IT department of Kozloduy. The setup, administration and backup strategy of the database must be conducted by the

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purchaser. In case of a desired network application, further workstations for each user, installation of the license and setup of configuration files is in responsibility of Kozloduy.

The warranty of the delivered work station will be 24 months from the date of Site Acceptance.

3.1.4 Software license key

The software is equipped with a hardware-based licensing of the company Thales. The protection ensures the proper use of the software license and safe execution of the program, since any manipulation of the core routines can be excluded by the encryption. License keys for ten (10) users are included in this offer.

3.2 General COMSY Software service

3.2.1 COMSY Basic Training Course

In order to enable Kozloduy engineers to work with the COMSY code, Framatome will perform a training course for up to ten (10) specialists on eight (8) working days at NPP, Kozloduy site. This also includes support and application's commissioning. The content of the basic training course will be:

- FAC Degradation Assessment process
- Plant data modeling
- Performance of a screening analysis utilizing the COMSY module for water chemistry cycle calculations, modeling of thermal circuits (including practical examples)
- Detailed modeling of systems and piping components (including practical examples)
- Flow-induced material degradation processes (in detail)
- Examination record management and NDT data evaluation (including practical examples)
- Document management
- Risk informed prioritization and inspection planning.

Training course will be provided in English language.

3.2.2 COMSY Software update service (Optional)

Framatome shall support Kozloduy by providing software upgrades and hotline service in case of minor handling problems via telephone, e mail and FTP-server for the relevant software modules for the time period of the service contract. The upgrade service cover compatibility with actual operating systems (e.g. Windows 11 successor) and/or improvements of the relevant software modules. By ordering the hotline and update service extension COMSY stays up-to date and further additional costs for software upgrades are inapplicable.

This service can be extended periodically to any desired time period that Kozloduy requires. (Refer to chapter 6.3). The software license itself is valid for the lifetime of the plant, see also 3.1.2.

Framatome guarantees that the software will perform its intended function until the end of the required long-term life of Unit 5 (2047) and Unit 6 (2051) only, if a continuous service agreement is existing between Framatome and Kozloduy until this date.

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3.2.3 User Group Meetings

The COMSY user group meetings, which are scheduled on a bi- or triannual basis, serve to exchange experience between COMSY license owners and Framatome. The meeting is held in English and also covers general aspects of plant life management and maintenance. As a COMSY license owner, Kozloduy becomes a full member of the COMSY user group and the participation is free of charge. Only travel expenses, daily allowances and accommodation of the participants have to be borne by the purchaser.

3.3 Summary of Deliverables

This chapter summarizes all deliverables by Framatome according to the requirements of TOR No. 23.EP-2.TZ.1252 (without the optional offered scope for module M3 and software update service):

- Delivery of a licensed software product for optimization of the activities related to aging management of the thermo-mechanical equipment in turbine department as explained in detail in chapter 3.1 based on the ordered modules, user interface in English and Bulgarian language and license keys for ten (10) users;

- Delivery of 1 (one) industrial workstation, see chapter 3.1.3;

- Personnel training, see chapter 3.2.1;

- User's Manual; (Operation and Maintenance Manual in the original language, 1 pc in English and 1 pc in Bulgarian language), see also chapter 3.1.2

- Non-Compliance Reports;

- Declaration/Certificate of Conformity;

- Declaration of origin;

- Protocol for completed installation on site;

- Protocol for completed training of KNPP personnel;

- Site test reports – result of validation test;

- System Acceptance Protocol – prepared after successful trial operation, defects and observations corrected from non-conformance reports, submittal of installation packages with reflected changes and documentation in accordance with the latest version of the system;

- Quality Assurance Programme (QAP);

- Quality Control Plan (QCP)/Quality Control and Testing Plan (QCTP)

- A statement/declaration that the software will perform its intended function until the end of the long-term life of Unit 5 (2047) and Unit 6 (2051), see chapter 3.2.2

4. Scope of supplies and services of the Customer

- Kozloduy appoints qualified persons to participate with the COMSY training course and workshop.

- Kozloduy appoints a person responsible for communication and transfer of documentation within the scope of the project.

- Kozloduy organizes workstations for each trained person with installed COMSY version and example databases (provided by Framatome) for the training at NPP Kozloduy site.

5.   Time schedule

For the intended project the following schedule shall be applicable upon Framatome's purchase order confirmation or final signature of the Contract for Work (B2) respectively.

Transfer of COMSY license, chapter 3.1.1, 3.1.2   confirm. of PO/sign of contract +   150 days

Start of basic training course, chapter 3.2.1   confirm. of PO/sign of contract +   150 days

The time schedule indicates latest points in time for project milestones. The actual schedule will be mutually agreed upon between Kozloduy and Framatome, considering possible limitations imposed.

6.   Price

This chapter provides the budgetary price information divided for the individual requirements from the tender.

The budgetary prices are estimated based on the descriptions and assumptions stated in this document and are non-binding.

All prices do not include any taxes such as VAT, duties and fees as eventually levied outside the Federal Republic of Germany.

6.1 COMSY Software Package for Erosion/Corrosion (EC) monitoring program

The scope of supplies and services of Framatome for COMSY software modules G1, G3, M1, M2, M6 and M7, Industrial workstation, license keys, training etc. as described in Chapters 3.1 and 3.3.

The estimated price for such supplies and services for Unit 5 and Unit 6 of Kozloduy amounts to:

383,000. -- €
(in words: three hundred eighty three thousand EURO)

6.2 Optional COMSY Software Package for Module M3 (Fatigue)

The scope of supplies and services of Framatome for the optional COMSY software module M3 as described in Chapter 3.1.1:

The estimated price for such supplies and services for Unit 5 and Unit 6 of Kozloduy amounts to:

44,300. -- €
(in words: forty four thousand three hundred EURO)

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6.3 Optional Software update and hotline service

The scope of supplies and services of Framatome for the optional Software update and hotline service as stated in Chapter 3.2.2.

Important note: A continuous service contract between Framatome and Kozloduy is the requirement for the guarantee that the software will perform its intended function until the long-term life of Unit 5 (2047) and Unit 6 (2051). The annual price will be subject to price readjustment over the years based on the inflation rate. If requested, also longer periods (longer than 1 year) can be quoted with pricing stability (e.g. firm price for 3 years).

The estimated price for such supplies and services for Unit 5 and Unit 6 of Kozloduy amounts to:

29,400. -- € per year
(in words: twenty nine thousand four hundred EURO)

7. Payment terms

Will be defined in the binding offer.

8. Validity

This budgetary quotation assumes a contract conclusion until December 31st, 2023.

9. Confidentiality

All information exchanged between Framatome and Kozloduy in connection with this project shall be treated confidentially, i.e. it shall not be disclosed to any third party without the written consent of the information provider. The distribution of technical data and price indications listed herein shall be limited to the staff within recipient's organization who need to know such data.

10. Miscellaneous terms

10.1 Terms and Conditions

Unless stipulated otherwise in this document, the Framatome GENERAL CONDITIONS FOR THE SUPPLY OF PRODUCTS AND SERVICES dated 2019-06-11, hereinafter referred to Framatome GTC's (Attachment 4) provide the basis for this budgetary quotation.

10.2 Waiver

This budgetary quotation which is non-binding and does neither constitute any obligation for nor imposes any liability on Framatome.

This is not an exclusive budgetary quotation and will in no case create an exclusive cooperation.

Prices stated in this document are purely indicative and are the best estimates at this point in time based on the information available to Framatome and may subject to modification.

11. **Contact persons**

For further information, please feel free to contact the following persons:

<u>Sales:</u>	Mr. Matthias Habelt Dep.: IBGVO	E-mail: Matthias.habelt@framatome.com Tel.: +49 (0) 9131 900 92693
<u>Technical:</u>	Mr. Roman Baier Dep. IBGSL1	E-mail: roman.baier@framatome.com Tel.: +49 (0) 9131 900 91995

We hope that our quotation meets your expectations and we remain at you disposition for any further clarification.

12. **Attachments**

Attachment 1:   **COMSY Product Information 2022**

Attachment 2:   **Copy of Framatome GmbH BDS EN ISO 9001 Certification**

Attachment 3:   **References of similar projects**

Attachment 4:   **General Conditions for The Supply of Products and Services; 2019-06-11**

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GENERAL CONDITIONS FOR THE SUPPLY OF PRODUCTS AND SERVICES

I.　　GENERAL

1. The scope of deliveries and/or services and works (hereinafter referred to as "**Delivery**" or, as the case may be, "**Deliveries**") shall be determined by the mutual written declarations of both Parties (hereinafter referred to as "**Contract**"). General conditions of business of the Purchaser shall apply only if and when expressly accepted by the supplier/provider (hereinafter referred to as "**Supplier**") in writing.

2. Partial Deliveries shall be allowed insofar as they are appropriate in consideration of both the Purchaser's and Supplier's interests.

3. The obligation of the Supplier to fulfill the Contract is under the proviso that all applicable export control, customs, embargo rules or other compulsory rules are fulfilled.

4. Where the Purchaser is a competitor to the Supplier (in whatever field of business), the Purchaser and the Supplier undertake to comply strictly with applicable antitrust rules and regulations and shall not in particular, discuss in the course of the present cooperation any other topics than those directly related to the subject matter of this Contract.

II.　　INTELLECTUAL PROPERTY RIGHTS / COPYRIGHTS

1. The Supplier herewith reserves any intellectual property rights, in particular patent rights, copyright and any unregistered proprietary rights in the information contained in its cost estimates, drawings and other documents (hereinafter referred to as "**Documents**"). Purchaser may only use the Documents and other information for the purpose for which it was provided, such as: the operation and maintenance of the plant where the Deliveries may be installed, used or integrated. The Documents must not be used for any other purpose. In particular they must not be used for other plants than that for which the Deliveries are determined or for production or reproduction of the Deliveries or parts of them. This includes copying the Deliveries on the basis of the originals and the production of parts and devices. The Documents shall not be made accessible to third parties without the Supplier's prior written consent and shall, upon request, be returned without undue delay to the Supplier if the contract is terminated or not awarded to the Supplier. This article shall apply mutatis mutandis to documents of the Purchaser; these may, however, be made accessible to third parties to whom Deliveries have been rightfully assigned by the Supplier.

2. The Purchaser shall have the non-exclusive, non-transferable, non-sublicensable right to use standard software, provided that it remains unchanged, is used within the agreed performance parameters, and with respect to the agreed equipment. No express agreement shall be necessary for the Purchaser to make two back-up copies.

III.　PRICES AND TERMS OF PAYMENT

1. Prices shall be ex-works and exclude packaging, turnover and value added and similar taxes and fees which arise from the conclusion of the contract or the associated works. Purchaser shall reimburse the Supplier for all those taxes and fees, which the Supplier and its sub suppliers have to pay.

2. Prices and time for Delivery shall be based on the applicable laws, technical codes and standards and the state of the art at the date of contract signature. The consequences of possible subsequent changes shall not be included in the prices or time of Delivery and shall be subject to Clause XVII below.

3. If the Supplier is also responsible for assembly or erection, and unless otherwise agreed, the Purchaser shall pay the agreed remuneration and any incidental costs required, for example travel costs, costs for the transport of tools and equipment, and personal luggage as well as accommodation allowances.

4. All payments shall be effected free of charge and without any deduction to the Supplier's bank account.

5. The Purchaser may set off only those claims that are undisputed or against which no recourse is possible.

6. If Purchaser is in delay with payment in whole or in part, Supplier is entitled – notwithstanding all his other rights - to interest for delay of 8 % (eight per cent) per annum pro rata above the annual base borrowing rate of the European Central Bank from the beginning of the delay insofar as the Supplier does not prove a higher damage.

IV. RETENTION OF TITLE

1. Items forming part of the Delivery ("Retained Goods") shall remain the property of the Supplier until the Purchaser has paid to the Supplier the price for the Delivery as well as all further monetary claims of the Supplier against the Purchaser in connection with the Delivery (retention of title). For the duration of the retention of title, the Purchaser is at his expense obliged to maintain the Retained Goods and to insure them for the benefit of the Supplier against theft, damage, fire, water and other risks. The Purchaser shall take all measures to ensure that the Supplier's title to the items in question is not lost, impaired or encumbered. If the Supplier loses the ownership of the Retained Goods, for example due to applicable laws, the Purchaser shall arrange that the Supplier is granted a lien on the sold Retained Goods until the price is paid and all other obligations of the Purchaser under this Contract are fulfilled. The Purchaser herewith authorizes the Supplier, to effect or to have effected all registration procedures or entries required by law concerning the retention of title or the lien in the respective public registers, books or similar records in accordance with all required formalities at the expense of the Purchaser. If the combined value of the collateral granted pursuant to the provisions above exceeds the value of all secured claims of the Supplier by more than 10 % (ten per cent), the Supplier shall release, on a pro-rata basis, the collateral if so requested by the Purchaser.

2. For the duration of the retention of title, the Purchaser may not pledge the Retained Goods or use them as security, and resale shall be possible only to resellers in the ordinary course of their business and only on condition that the reseller receives payment from its customer or makes the transfer of property to the customer dependent upon the customer fulfilling its obligation to effect payment.

3. The Purchaser shall inform the Supplier forthwith of any seizure, confiscation or any other act of intervention by third parties which may have the effect that the Supplier loses the ownership or a lien on the Retained Goods.

4. Where the Purchaser fails to fulfill its obligations, including failure to make due payments, the Supplier shall be entitled to rescind the contract and take back the Retained Goods. In this case, the Purchaser shall give back the Retained Goods. Taking back the Retained Goods, or claiming the rights related to the retention of title does not require a rescission of the contract. Such actions or a seizure executed by the Supplier must not be interpreted as a rescission or termination of the contract, unless the Supplier declared this explicitly. The Purchaser shall be liable for the costs incurred by the Supplier due to rescission.

V. TIME FOR DELIVERY; DELAY

1. Time-limits set for Delivery can only be observed if all Documents to be supplied by the Purchaser, necessary permits and releases, especially concerning plans, are received in time and if agreed terms of payment and other obligations of the Purchaser are fulfilled. Unless these conditions are fulfilled in time, time limits shall be extended appropriately; this shall not apply where the delay is solely attributable to the Supplier.

2. If non-observance of the time limits is due to a force majeure event, which means obstacles or circumstances the Supplier cannot – within reasonable diligence – influence, or due to strike or lockout, the duty to fulfill the Contract is temporarily suspended and the period of delivery is extended by the duration of the force majeure event, the strike or the lockout and the consequences arising therefrom.

3. If a force majeure event, a strike or a lockout lasts longer than 30 (thirty) days, the Supplier is entitled to payment by the Purchaser of the price for the Deliveries that have been effected until the force majeure event occurred and to reimbursement of the unavoidable costs incurred in connection with the performance of the Contract, such as costs incurred by the contracting of subcontractors. The right to terminate the Contract in accordance with Article XV. No. 2 d) remains unaffected.

4. Force majeure events for the purposes of this Contract are in particular natural disasters or other events such as but not limited to epidemics, nuclear incidents, fire, explosion, flooding, storm, earthquake, acts or omissions of civil or military authorities, restraints of foreign exchange, revocation or suspension of export or import licenses or governmental privileges, allocation or restraints in use of material or manpower, war (with or without declaration of war), rebellion, sabotage, revolution or terrorist attack even if their occurrence only impends, shortage of means of transport such as trucks, railway carriages, ships, planes, shortage of fuel or energy and delays or accidents in connection with the dispatch or transport.

5. If a delay is solely attributable to the Supplier and the Purchaser can prove that he has suffered a loss therefrom, the Purchaser may claim a compensation of 0.5% (zero point five per cent) for every completed week of delay, but in no case more than a total of 5% (five per cent) of the price of that part of the Delivery which could not be put to the intended use because of the delay. The payment of this

compensation shall be the sole and exclusive remedy for the Purchaser in case of delay.

6. Purchaser's claims for damages exceeding the limits specified in No. 5 above shall be excluded in all cases of delayed Delivery even upon expiry of a time limit set to the Supplier to effect the Delivery. If a delivery deadline is agreed upon and the Supplier is in delay, the Purchaser does not waive the Delivery.

7. If dispatch or shipment is delayed for reasons not attributable to the Supplier by more than one month after notice of the readiness for dispatch was given, the Purchaser may be charged, for every month commenced, storage costs of 0.5% (zero point five per cent) of the price of the items of the Delivery. The Parties to the Contract may prove that higher or, as the case may be, lower storage costs have been incurred.

8. If the delay of delivery is attributable to the Purchaser, the Purchaser shall reimburse all additional costs incurred because of the delay.

VI. TRANSFER OF RISK

1. Even where Delivery has been agreed with shipment cost borne by the Supplier, the risk of accidental loss or damage shall pass to the Purchaser as follows:

   a) if the Delivery does not include assembly or erection, at the time when the Delivery is picked up by the Purchaser in the works of the Supplier. Upon request of the Purchaser, the Supplier shall insure Deliveries against the usual risks of transport at the expense of the Purchaser;

   b) if the Delivery includes assembly or erection, at the day of completion of the assembly or erection at the place of destination or, if so agreed, after a fault-free trial run.

2. The risk shall pass on to the Purchaser on the dates as foreseen in No. 1, if collection, dispatch, shipping, the start of performance or completion of assembly or erection, or the trial run is delayed for reasons attributable to the Purchaser or if the Purchaser has otherwise failed to accept Delivery.

VII. DELIVERIES OUTSIDE THE WORKS OF THE SUPPLIER

Unless otherwise agreed in writing, assembly and erection and other services including warranty work, which are performed outside the works of the Supplier shall be subject to the following provisions:

1. The Purchaser shall provide at its own expense and in good time:

   a) that all permits necessary for the performance of the Deliveries are granted and available,

   b) the unrestricted access to the area of work and to the Deliveries including in particular the provision of access and security cards,

   c) comprehensive support for import, export and customs clearance of personal belongings of the personnel of the Supplier, its sub-suppliers and of all tools and goods which are necessary for the Deliveries,

   d) as far as necessary, comprehensive support of the personnel of the Supplier, its sub-suppliers for the procurement of Visa, work and residence permits for entry into the country and for the procurement of the necessary permits on leaving the country,

   e) assistance in repatriation of the personnel of the Supplier, his sub-suppliers in cases of emergency, for example war, civil war, political turmoil or epidemics,

   f) all earth and construction work and other ancillary work outside the scope of the Supplier, including the necessary skilled and unskilled labor, construction materials and tools,

   g) the equipment and materials necessary for assembly and commissioning such as scaffolds, lifting equipment and other devices as well as fuels and lubricants,

   h) electric power and other energy as well as water at the point of use including connections, heating and lighting,

   i) suitable dry and lockable rooms of sufficient size adjacent to the site for the storage of machine parts, apparatus, materials, tools, etc. and adequate working and recreation rooms for the erection personnel, including sanitary facilities as are appropriate in the specific circumstances. Furthermore, the Purchaser shall take all measures he would take for the protection of its own possessions to protect the possessions of the Supplier and of the erection personnel at the site,

j) protective clothing and protective devices needed due to particular conditions prevailing on the specific site,

k) that the area of work is free from any health and safety risks, which go beyond that what is normal and usual for the type of Deliveries to be performed by the Supplier,

l) all necessary measures for the protection of health and safety of the personnel of the Supplier and his sub-suppliers and

m) all necessary measures of decontamination and radiation protection insofar as they are necessary for the fulfillment of the Supplier's contractual obligations. This includes the decontamination of devices or tools of the Supplier, which were used for the fulfillment of these obligations.

2. If site or activity related health and safety risks – for example due to asbestos – are identified or if there is a reasonable suspicion that such risks exist or arise during the performance of the Contract or if the Purchaser does not fulfill his obligations under No. 1 j), k), l), or m) of this Article VII., notwithstanding other claims, the Supplier is entitled to suspend the performance of the Contract until the health and safety risk is permanently eliminated, the reasonable suspicion is proven to be ungrounded or protective or preventive measures agreed between the parties are adopted.

3. Before the erection work starts, the Purchaser shall, unsolicited at its own expense, make available to the Supplier all necessary information, such as information concerning the location of concealed electric power, gas and water lines or of similar installations as well as the necessary data on statics and on the composition of the ground.

4. Prior to assembly or erection, the Purchaser has to ensure at its own expense that the materials and equipment necessary for the work to start are available on the site of assembly/erection and any preparatory work has advanced to such a degree that assembly/erection can be started as agreed and carried out without interruption. Access roads and the assembly/erection site itself must be at level and clear.

5. If assembly, erection or commissioning is delayed due to circumstances beyond the Supplier's control, the Supplier is entitled to a reasonable adaption of the deadlines, the price and other stipulations of the Contract affected thereof.

6. For Deliveries, remunerated on the basis of time, material and other expenditures, the Purchaser shall, upon request by the Supplier, attest at weekly intervals the hours worked by the erection personnel and he shall upon request by the Supplier immediately confirm in writing the completion or progress of assembly, erection or commissioning.

7. The Purchaser shall dispose of all waste occurring on the site in time and in compliance with all applicable laws. Furthermore the Purchaser shall in time and in compliance with applicable laws dispose of his installations or parts thereof which are or become waste that requires particular surveillance. Notwithstanding the abovementioned, the Supplier is obliged to pay the Purchaser the additional costs for disposal of waste negligently caused by the Supplier on the site of the Purchaser, insofar as these costs are considerable. In any case the Purchaser is at its own expense responsible for decontamination and/or disposal of radioactive materials or waste.

VIII. ACCEPTANCE

1. Upon request of the Supplier, the Purchaser shall at each time separately declare acceptance after performance of the planning, a factory acceptance test, the erection, assembly, commissioning and the performance tests.

2. Notwithstanding the provisions in this Article VIII. the Purchaser shall declare acceptance of the Deliveries upon request of the Supplier, except in the case where a Delivery has major defects or major parts of the Delivery are missing and the Purchaser informs the Supplier thereof in writing immediately after receiving the Delivery. Consequently, minor defects of the Delivery shall not entitle the Purchaser to withhold acceptance of the concerned Deliveries.

3. After receipt of the Deliveries and the shipping papers, the Purchaser shall check the Deliveries and inform the last carrier in writing – sending a copy to the Supplier – about transport damages or other complaints concerning transport and the Purchaser shall take evidence of damages or complaints and document them with photographs.

4. If after completion the Supplier requests acceptance of the Delivery or parts thereof, the Purchaser shall

declare acceptance in writing within 2 (two) weeks after the request. Otherwise acceptance is deemed to have taken place. Acceptance likewise is deemed to have taken place if the Purchaser takes the Deliveries into commercial use or rejects acceptance but does not within the abovementioned two weeks period provide reasons for its denial in writing. The reasons to be provided by the Purchaser have to include at least explanations as to which Delivery or which parts thereof the Purchaser does regard as significantly deficient or not completed and why the Purchaser is of this opinion.

5. The Purchaser must not deny acceptance of the Deliveries

   a. because of defects that only negligibly impair the use of the respective Delivery,

   b. because of minor deviations from the technical description,

   c. in case of improper assembly or erection of the Deliveries by a party different from the Supplier, or

   d. due to defects caused by insufficient foundations or extraordinary external influences which, concerning the Deliveries, were not indicated explicitly to be taken into consideration.

6. Acceptance may not be finally rejected, unless the defect cannot be remedied and the Supplier has clearly denied remedying the defect.

7. If the Delivery or a part thereof are completed or ready for delivery and if they - for reasons not attributable to the Supplier – cannot be delivered or commissioned, acceptance is deemed to have taken place, once the Supplier has informed the Purchaser of his readiness to ship or to putting into operation.

8. In any case acceptance is deemed to have taken place if the Purchaser does not attend acceptance proceedings described in this Contract or once the Purchaser puts the Deliveries into commercial operation.

9. All costs and expenditures for actions taken by the Supplier or third parties in connection with examinations, checks, permits, acceptance proceedings and the like have to be borne by the Purchaser.

IX. DEFECTS AS TO QUALITY

1. The Supplier shall be liable for defects as to quality (hereinafter referred to as "**Defects**", or as the case may be "**Defective**") as follows:

   a) where all Deliveries or parts thereof become defective and a notice of the specific Defect is given by the Purchaser to the Supplier, both within the limitation period as defined in Art. IX.1.c), the Supplier shall, at its discretion, repair, replace or provide such Deliveries again free of charge, provided that the reason underlying the Defect had already existed at the time when the risk passed (Art. VI. TRANSFER OF RISK).

   b) The Purchaser and the Supplier agree that the Supplier only warrants that the Deliveries have the properties, and are suitable for the use which are explicitly described by the Supplier in his offer. No other warranty with respect to the quality of the Deliveries is provided by the Supplier. The Supplier in particular neither warrants that the Deliveries are suitable for usual utilization, nor that the Deliveries have such properties which are usual for Deliveries of the same nature or which the Purchaser could expect according to the nature of the Delivery. The Purchaser and the Supplier agree that all descriptions of the Deliveries, all performance specifications, all specifications and features in this offer including its attachments and enclosures do not contain any implied guarantees.

   c) Claims based on Defects are subject to a limitation period of 12 (twelve) months. This limitation period shall begin with the delivery of the purchased goods or with acceptance of the works or at the time of the deemed acceptance as defined in Art. VIII (ACCEPTANCE), as the case may be, and shall, also for re-performed, repaired or replaced Deliveries, in no case exceed 24 (twenty four) months from the beginning of the initial limitation period.

   d) The Purchaser shall notify a Defect to the Supplier in writing and without undue delay after its discovery.

   e) In the case of notification of a Defect, Purchaser's payments may be withheld to a reasonable extent taking into account the Defect. The Purchaser, however, may withhold payments only if the subject matter of the written notification of the Defect is justified beyond doubt. Unjustified notifications of Defect or notifications - which upon investigation prove to be such - shall entitle the Supplier to have its expenses reimbursed by the Purchaser.

   f) The Supplier shall first be given the opportunity to re-perform (including repair or replacement) within a reasonable period of time.

g) If supplementary performance after the second attempt is still unsuccessful, the Purchaser shall be entitled to terminate the contract or to reduce the remuneration. He may claim damages – if any – only within the limits described in Article XII (OTHER CLAIMS FOR DAMAGES). The Purchaser is not entitled to reimbursement for expenses incurred through such unsuccessful supplementary performance.

2. The Supplier shall not be liable for claims based on Defect

   a) in cases of insignificant deviations of the Deliveries from the agreed quality or of only minor impairment of usefulness or of natural wear and tear,

   b) in cases of Defects to component parts, apparatuses or services which have been provided by the Purchaser except if the Supplier has explicitly committed himself in the Contract to remedy this Defect.

   c) in cases of Defects to consumables or wear and tear parts which are to be replaced regularly after transfer of risk because of wear and tear,

   d) for damages arising from faulty or negligent handling, excessive strain, unsuitable equipment or any other inappropriate use by the Purchaser or any third party,

   e) if the Purchaser cannot prove that he has complied with the instructions of the operation and maintenance manual or other documents of the original manufacturer and the Supplier,

   f) if the Purchaser or a third party carries out modifications to, or repair work on the Deliveries,

   g) if the Purchaser does not notify the Supplier of a defect occurring within the limitation period immediately after he has discovered it or after he should have discovered it exercising reasonable diligence,

   h) if the Purchaser did not take all measures necessary to keep the damage as small as possible,

   i) if the Purchaser has prevented the Supplier from remedying the Defect,

   j) in cases of non-reproducible software errors, errors in shareware, freeware or open source software, or

   k) in cases of damage caused by inappropriate foundation soil or from particular external influences not assumed under the Contract.

3. The Purchaser shall have no claim with respect to expenses incurred in the course of supplementary performance, including costs of travel and transport, labor, and material, to the extent that his expenses become higher because the subject-matter of the Delivery was subsequently brought to another location than the Purchaser's business establishment.

4. The Purchaser's right of recourse against the Supplier is limited to the claims based on Defects defined in this Article IX. (DEFECTS AS TO QUALITY).

5. The Purchaser shall ensure at its own expense access to the site, area of work and the material for work related to remedying Defects.

6. The Purchaser shall ensure at its own expense the disposal of parts and materials arising from work related to remedying Defects.

7. The Purchaser shall ensure at its own expense all necessary decontamination related to work related to remedying Defects.

8. Any claims for Damages based on Defects are subject to Article XII (OTHER CLAIMS FOR DAMAGES).

9. Other or further claims based on a Defect, of the Purchaser against the Supplier or its agents than those explicitly provided for in this Article IX. are excluded.

10. Purchaser's right of substitute performance under Art. 366 para. 2 Code of Obligations is excluded.

X. INDUSTRIAL PROPERTY RIGHTS AND COPYRIGHT; DEFECTS OF TITLE

1. Unless otherwise agreed, the Supplier shall supply the Delivery free from third parties' industrial property rights and copyrights (hereinafter referred to as "**IPR**") with respect to the country of the place of destination. If a third party lodges a justified claim against the Purchaser based on an infringement of an IPR with respect to a Delivery made by the Supplier and then used in conformity with the Contract, the Supplier shall be liable to the Purchaser within the time period stipulated in Article IX. No. 1 c) as follows:

a) The Supplier shall choose whether to acquire, at its own expense, the right to use the IPR with respect to the Delivery concerned or whether to modify the Delivery such that it no longer infringes the IPR or replace it. If this would be unreasonable to demand from the Supplier, the Purchaser may withdraw from the Contract or reduce the contract price pursuant to the applicable statutory provisions. The Purchaser is not entitled to reimbursement for expenses incurred due to unsuccessful performance.

b) The Supplier's liability to pay damages shall be governed by Article XII.

c) The above obligations of the Supplier shall not apply unless the Purchaser (i) immediately notifies the Supplier of any such claim asserted by the third party in writing, (ii) does not concede the existence of an infringement, (iii) provides the Supplier with the necessary power of attorney, information and support in order to repel the claim or to solve the dispute in another appropriate way, and (iv) leaves any protective measures and settlement negotiations to the discretion of the Supplier. If the Purchaser stops using the Delivery in order to reduce the damage or for other good reason, he shall be obliged to point out to the third party that no acknowledgement of the alleged infringement may be inferred from the fact that the use has been discontinued.

2. Claims of the Purchaser shall be excluded if he is itself responsible for the infringement of an IPR.

3. Claims of the Purchaser shall also be excluded if the infringement of the IPR was attributable to specifications made by the Purchaser, to a type of use not foreseeable by the Supplier or to the Delivery being modified by the Purchaser or being used together with products not provided by the Supplier.

4. Where other defects of title occur, Article IX (DEFECTS AS TO QUALITY) shall apply mutatis mutandis.

5. Subsequent and/or other claims by the Purchaser against the Supplier and/or its agents based on a defect in title not provided for in this Article VIII are excluded.

XI. IMPOSSIBILITY OF PERFORMANCE; ADAPTATION OF CONTRACT

1. To the extent that Delivery is impossible, the Purchaser shall be entitled to claim damages, provided that the impossibility is attributable to the Supplier. The Purchaser's claim for damages shall, however, be limited to an amount of 10% (ten per cent) of the value of the part of the Delivery which, due to the impossibility, cannot be put to the intended use. The compensation due under Article V. No. 3. shall be deducted from the claim for damages.

2. If Delivery is temporarily not possible, Article V (TIME FOR DELIVERY; DELAY) shall apply.

3. The Supplier shall be entitled to a reasonable adjustment of the Contract in case, after the submission of the offer, changes in the applicable laws, technical codes and standards, safety or security rules, decisions or requirements of authorities or courts or the state of the art impact the obligations of the Supplier; especially when the economic significance or the contents of the Delivery are affected or the Supplier's business is impaired.

4. The Supplier shall be entitled to a reasonable adjustment of the Contract in cases of force majeure, strike or lockout according to Article V (TIME FOR DELIVERY; DELAY).

5. An adjustment in the meaning of the above No. 3 and 4. includes - according to the individual circumstances - the adjustment of the contract price and the modification of the time for delivery or completion.

XII. OTHER CLAIMS FOR DAMAGES

1. Supplier's aggregate total liability (encompassing all liabilities and remedies) arising out of or in connection with this Contract based on whatever legal reason, including breach of obligations or duties arising out of or in connection with the Contract, or tort, shall be limited to the Price of the Deliveries.

2. The Supplier is not liable for

a) Indirect or consequential damage or loss of production, loss of use, loss of profit, loss of opportunity, loss of information or data, stoppage of energy production or distribution, cost of replacement energy

b) claims by Purchaser based on claims by his customers or other suppliers.

3. Supplier shall only be liable for loss or damage in case of fault.

4. In case Supplier has agreed to payment of a penalty, then this penalty shall only be payable if actual damage has been incurred. The payment of a penalty shall be the sole and exclusive remedy for

Purchaser in such case of nonconformance.

5. Purchaser shall hold Supplier harmless for any claims based on any emissions and Environmental harm caused by the fulfillment of the Contract.

6. All liability of the Supplier arising out of this Contract ends upon expiry of the limitation period for Defects set out in Article IX. 1c) and the total cumulative liability of the Supplier shall in no case exceed the respective Price of the Deliveries.

7. Nuclear third party liability shall be in accordance with the statutory requirements. The Purchaser waives any claims against the Supplier for any damage incurred through a nuclear incident. If the Deliveries are intended for a plant of the Purchaser which constitutes a nuclear facility, the Purchaser also indemnifies the Supplier from claims by third parties for any damage incurred through a nuclear incident when property of the said third parties is at the Purchaser's nuclear facility. The Purchaser shall in no case make representations designating the Supplier as owner or operator of the nuclear facility and the Supplier shall under no circumstances be deemed owner or operator of the nuclear facility.

8. If the Deliveries executed by the Supplier are dispatched to a nuclear facility - either by the Supplier, the Purchaser or a third party – which is not the property of the Purchaser, the Purchaser holds harmless and indemnifies the Supplier from all claims made by third parties (including the owner and the operator of such nuclear facility) owing to nuclear on-site property damage as well as from claims by third parties who's property is present at the nuclear facility.

9. The above liability regulations shall apply also to the benefit of all subcontractors and subsuppliers of the Supplier as well as their personnel and their respective subcontractors and sub-suppliers of any tier, including their personnel.

10. The limitations and exclusions of liability contained in these conditions shall apply to the largest legally permitted extent, also to damages caused by auxiliary persons, including sub-suppliers, of the Supplier.

XIII. CONFIDENTIALITY

1. Any information and data of a confidential nature, including, but not limited to, technical, research, developmental, manufacturing, operating, performance, cost, or process information and know-how, samples, models, apparatus, if any, and all data bearing media containing such information and techniques (hereinafter referred to as "**Confidential Information**") which are made available by Supplier pursuant to this Contract shall not be copied or disclosed to any third party by the Purchaser without the express prior written consent of Supplier. Purchaser shall ensure that his employees only receive Confidential Information on a need-to-know basis who must be adequately informed of the obligations of Purchaser and who are bound to confidentiality either by their employment agreement or otherwise to an extent not less stringent than the obligations under this Contract. The Confidential Information shall be treated by Purchaser with necessary care to avoid disclosure to third parties, but at least with the same degree of care as used with respect to receiving party's own Confidential Information of equal importance. The Supplier is entitled to disclose Confidential Information of the Purchaser to his advisers, agents, suppliers and subcontractors to the extent necessary to fulfill this Contract. These confidentiality undertakings shall survive the expiration or termination of the Contract except as otherwise agreed.

2. The foregoing obligations shall not apply to any information when Purchaser can evidence that the information

   a) at the time of disclosure is in, or, without breach of this Contract, later becomes part of the public domain; or

   b) is legally obtained by Purchaser from a third party without an obligation of confidentiality; or

   c) was known to Purchaser without an obligation of confidentiality prior to the receipt of the Confidential Information from Supplier or is independently developed later by Purchaser; or

   d) is required to be disclosed to comply with a judicial or official order or decree after all available legal remedies to maintain the Confidential Information in secret have been exhausted; provided that advance notice of such judicial action was timely given to Supplier.

XIV. SUSPENSION

1. The Supplier may suspend the performance of the Contract at his option if

   a) the Purchaser is in delay of payment thirty (30) days after the due date,

   b) the Purchaser fails to fulfill duties that are necessary in order to deliver or complete the Deliveries,

c) a condition in respect of the Purchaser arises as described in Article XV. No.1.

2. If the Supplier suspends the performance of the Contract according to Art. XIV No.1 the time for delivery is extended at least by the duration of the suspension and the time of re-mobilization, and the Purchaser shall compensate the Supplier for all work performed up to the receipt of notice of suspension, as well as pay all expenses incurred due to the suspension, in particular storage costs, project extension costs, de- and re-mobilization costs, and the respective interest for delayed payment.

XV. TERMINATION

1. Each Party is entitled to terminate the Contract if:

   a) bankruptcy or insolvency proceedings are initiated against the other Party on whoever's request, or if the other Party makes a general assignment for the benefit of its creditors, or if a receiver or trustee is appointed for the other Party, or any similar instrument of national law is applied, or the other Party ceases its activities,

   b) there is a substantial breach of an obligation under this Contract by the other Party. If the breach can be remedied, then the Contract can only be terminated after prior written notice setting a reasonable time to cure the breach. The Contract can only be terminated for a delay due to the Supplier after the liability limit according to Article V No. 5 has been reached and the Purchaser has set a reasonable final date in writing with explicit notice of intention to exercise the right to termination.

2. Moreover, the Supplier may terminate the Contract without any further liability:

   a) if the Purchaser becomes directly or indirectly controlled by a competitor of Supplier,

   b) if the Purchaser assigns any rights under the Contract to another party, or

   c) if the suspension under Article XIV exceeds 60 (sixty) days

   d) if the circumstance of force majeure, strike or lockout under Article V. 3 exceeds a period of 90 (ninety) days or

   e) when an adjustment of the Contract under Article XI. No. 3, within the reasonable opinion of the Supplier is not economically possible and if the Supplier has notified Purchaser immediately of this upon being informed of such an event.

3. Should the Purchaser be entitled to terminate the Contract under No. 1, then the Purchaser's claims vis-à-vis the Supplier shall be limited to an amount similar to the price already paid and according to Article XII. The price for the part of the Deliveries performed up to termination shall be paid.

4. Not used

5. Any termination must be declared in writing. The termination rights expressly agreed in the Contract (including this General Conditions) shall be the parties' sole rights to terminate the Contract, only excluding the Purchaser's termination right for convenience in accordance with Article 377 Code of Obligations. Any further termination right under the applicable law, in particular Art. 107 and Art. 366 Code of Obligations shall be excluded.

6. In case of termination of the Contract by the Supplier as per No. 1 and/or No. 2 of this Article XV, as well as in case of termination for convenience by the Purchaser , the Supplier shall be entitled to receive:

   a) the agreed price for the Deliveries performed up to the date of termination. To the extent the agreed price for the Deliveries performed up to the date of termination cannot be taken from the express stipulations in the Contract, the Supplier shall be entitled to reasonably determine, under due consideration of individual tasks already performed and material or goods already produced or ordered under the contract, the part of the agreed overall price, which is payable for the Deliveries performed up to the date of termination ,

   Such materials or goods shall become the property of and be the risk of the Purchaser when paid for by the Purchaser and the Supplier shall place the same at the Purchaser's disposal,

   b) the amount of any other reasonable expenditure incurred or already committed by the Supplier in the expectation of completing the whole of the Deliveries,

   c) the reasonable cost of removal of the Supplier's equipment from site and the return thereof to the Supplier's works in his country or to any other destination at no greater cost, and

   d) the reasonable cost of repatriation of the Supplier's staff and workmen employed wholly in

connection with the Deliveries at the date of such termination and

e) adequate loss of profit (by default 10% of the price for the part of the Deliveries which are no longer executable due to the termination).

XVI. RESCISSION

Without prejudice to Article IV. No. 4, any other right to rescind the Contract is excluded.

XVII. CHANGES

1. Any changes or modifications to the provisions of the Contract shall be subject to the prior written approval of both Parties and set forth in a written amendment duly signed by the Parties, except as otherwise provided for in the Contract. In no case shall the Supplier have the obligation to implement such changes or modifications without a prior written agreement of the Parties.

2. In the event of a change in laws and/or regulations in the Purchaser's country, including but not limited to codes, standards and safety regulations applicable to the performance of the Contract, which affects in whole or in part the performance of Supplier's obligations after the submission of the binding Supplier's offer to the Purchaser, the Purchaser shall immediately inform the Supplier in writing about such changes. To the extent such changes have to be implemented due to mandatory law, the Supplier shall be entitled to implement such changes immediately.

3. In case of changes according to Article XVII. Supplier is entitled to an equitable adjustment of the contractual provisions affected, especially but not limited to Contract price and project time schedule.

XVIII. DISPUTE RESOLUTION AND APPLICABLE LAW

1. The Parties shall endeavor to amicably settle any dispute arising out of or in connection with the Contract, including any question regarding its existence, validity or termination and including its performance and any arrangements relating thereto (except as expressly otherwise agreed for such arrangements). In their attempt to settle any dispute amicably the Parties shall contemplate, but not be obliged, to seek settlement by mediation under rules to be agreed upon. An attempt to arrive at a settlement shall be deemed to have failed as soon as one of the Parties so notifies the other.

2. All disputes arising out of or in connection with the Contract , for which amicable settlement as per No.1 has failed, shall be finally and exclusively settled under the Rules of Arbitration of the International Chamber of Commerce. The place and seat of arbitration is Zurich, Switzerland. The procedural law of this place shall apply where the said Rules are silent. Proceedings shall be conducted in English.

3. The Contract and any disputes arising out of or in connection with the Contract shall be governed by Swiss substantive law, whereas the application of the United Nations Convention on Contracts for the International Sale of Goods (CISG) shall be excluded.

XIX. SEVERABILITY CLAUSE

The legal invalidity of one or more provisions of this Contract shall in no way affect the validity of the remaining provisions. This shall not apply if it would be unreasonable for one of the Parties to continue the Contract.

References

The COMSY software provides the platform for a number of applications and functionalities on the field of aging and plant life management. It is a software product with modular architecture, which is designed in a way where each module can be operated independently or in combination with any number of further modules.

The software program COMSY is designed to provide prognosis of degradation processes in the technical equipment of power plants. The program does not only store and manage data, but also provides a number of analytical functions. Based on the input data, it provides prognosis of e.g. critical points; predicts degradation rates and performs lifetime analysis for components. On this basis the in-service inspections and maintenance activities can be optimized.

Flow Accelerated Corrosion Applications

For the analysis of the FAC potential of mechanical components, Framatome GmbH has developed the COMSY software system which incorporates a FAC model, which is based on laboratory experiments and comprehensive experience gained from field applications. The FAC model is continuously updated and improved in order to consider the current state of knowledge on the field of FAC.

This configuration corresponds to the specification in the Terms of Reference (TOR) No. 23.EP-2.TZ.1252.

The software module on FAC is implemented in the following power plants:

PWR / VVER
- Nederland / Borssele
- Slovakia: Mohovce, Bohunice
- China: CGN
- Germany: Isar, Grohnde, Brokdorf
- Switzerland: Gösgen
- Japan: Tomari 1 and 2
- Hungary: Paks 1, 2, 3 and 4
- Bulgaria: Kozloduy
- Brasil: Angra 1 and 2
- Finnland: Olkiluoto 3, Loviisa 1 and 2

BWR
- Sweden: Forsmark 1, 2 and 3
- Switzerland: Leibstadt
- Spain: Cofrentes, St. Maria de Garona

PHWR / CANDU
- Argentina: Atucha 1 and 2, Embalse

Aging Management (AM) and Long Term Operation (LTO) Applications

FRAMATOME provides the COMSY software for aging and plant life management. The software enables the design and setup of a computerized power plant knowledge base with analytical capabilities. Lifetime Management and degradation assessment is very complex. Sophisticated tools save time and deliver more accurate results. Framatome tools provide efficient living aging management programs with feedback loop based on inspection results and reported events.
- COMSY- Mechanical
  predicts degradation effects and optimizes inspections
- COMSY- Electrical
  determines the remaining life of electrical equipment and I&C

Framatome GmbH, 91058 Erlangen, Germany

- COMSY- Civil
  systematic maintenance management of civil structures
- Automatic commodity grouping according to IAEA IGALL or US GALL
- Degradation assessment of plant equipment
- Risk Informed Inspection Planning
- AMP Management
- Operating experience module
- Integrated document management
- COMSY – Active
  Predictive maintenance, RCM methodology
- IDEX Monitoring and Diagnostic expert tools
  condition monitoring of key components

The software module on AM and LTO are implemented in the following power plants:
- Slovenia: Krsko
- Ukraine: Khmelnitzky 2
- Argentina: Atucha 1 and 2, Embalse
- Germany: ISAR 1 and 2, Phillipsburg 1 and 2
- Switzerland: Gösgen
- South Africa: Koeberg 1 and 2
- Nederland / Borssele
- United Kingdom: Sizewell B

Software Interface Development

In order to effectively integrate a specific software solution in an existing uniform IT environment interfaces to different software solutions are necessary. Therefore, several interfaces where realized for dissimilar software systems at different NPPs.
These are,
- Germany:
  - Phillipsburg NPP, interface to SAP system
  - ISAR NPP, interface to documentation system, support database, maintenance database,
- South Africa
  - Koeberg NPP, Import of equipment and inspection data from multiple sources
- Nederland
  - Borssele, Import of data from Asset Suite
- United Kingdom
  - Sizewell B; Import of data from AMS System

Framatome GmbH, 91058 Erlangen, Germany

Certificat

Certificate

AFNOR Certification certifie que le système de management mis en place par :
AFNOR Certification certifies that the management system implemented by:

FRAMATOME

pour les activités suivantes :
for the following activities:

VENTES, RECHERCHE ET DEVELOPPEMENT, CONCEPTION, QUALIFICATION, APPROVISIONNEMENT, FABRICATION, CONSTRUCTION, ESSAIS, INSTALLATION, MISE EN SERVICE ET ACTIVITES DE SERVICES ET DE MAINTENANCE POUR LE COMBUSTIBLE NUCLEAIRE, LES NOUVEAUX PROJETS DE CENTRALES NUCLEAIRES, LES INSTALLATIONS NUCLEAIRES EN FONCTIONNEMENT, LES REACTEURS DE RECHERCHE AINSI QUE POUR D'AUTRES SECTEURS INDUSTRIELS.

CONCEPTION ET FABRICATION D'EQUIPEMENTS D'APPAREILS SOUS PRESSION & SYSTEMES & COMPOSANTS ET EQUIPEMENTS, SOURCES RADIOACTIVES, ETALONS ET INSTRUMENTATION DE CŒURS (CAPSULE IRRADIATION, DOIGTS DE GANTS), SERVICES D'INGENIERIE, ETUDES ET FABRICATION D'INSTRUMENTATION DE CONTROLE COMMANDE ET DE SYSTEME ELECTRIQUE, SERVICES EN ARRET DE TRANCHE, REMPLACEMENT ET REPARATION DE SYSTEMES, COMPOSANTS ET D'EQUIPEMENTS, PIECES DE RECHANGE, EXAMENS NON DESTRUCTIF, TRAITEMENTS CHIMIQUES ET TRAITEMENT DES DECHETS, DECONTAMINATION, DEMANTELEMENT, SYSTEMES DE SURVEILLANCE ET D'AIDE AU DIAGNOSTIC, ESSAIS FONCTIONNELS, FORMATION NUCLEAIRE, EXPLOITATION ET MISE A DISPOSITION D'ATELIER DE MAINTENANCE NUCLEAIRE, ENTREPOSAGE ET ORGANISATION DE TRANSPORTS DE MATERIELS RADIOACTIFS.

FABRICATIONS DE PIECES EN ACIERS ALLIES, ACIERS SPECIAUX, ACIERS INOXYDABLES, SUPER ALLIAGES, ACIERS BASE Ni, ACIERS A OUTIL, DE ZIRCONIUM ET DE SES ALLIAGES AINSI QUE D'AUTRES METAUX REFRACTAIRES (TEL QUE HAFNIUM, TITANE, NIOBIUM, TANTALE) ET DE PRODUITS DERIVES (TELS UE MgCl2, ZrO2). CES FABRICATIONS COUVRENT LES OPERATIONS DE FORGEAGE, MOULAGE, FLUO TOURNAGE A CHAUD, USINAGE, TRAITEMENTS THERMIQUES, CONTROLES DIMENSIONNEL, ESSAIS DESTRUCTIFS ET NON DESTRUCTIFS, ANALYSES CHIMIQUES.

Traduction des activités en annexe / *Activities translated on appendix*

a été évalué et jugé conforme aux exigences requises par :
has been assessed and found to meet the requirements of:

ISO 9001 : 2015

et est déployé sur les sites suivants :
and is developed on the following locations:

1, place Jean Millier   Tour AREVA   FR-92400 COURBEVOIE

Liste des sites certifiés en annexes / *List of certified locations on appendices*

Ce certificat est valable à compter du (année/mois/jour)
This certificate is valid from (year/month/day)   **2022-02-24**

Jusqu'au
Until   **2023-07-04**

SignatureFournisseur

Julien NIZRI
Directeur Général d'AFNOR Certification
Managing Director of AFNOR Certification

Flashez ce QR Code pour vérifier la validité du certificat

Annexe / *Appendix* **n° 1**

FRAMATOME

Détail des activités mises en œuvre :
Details of the activities carried out:

SALES, RESEARCH AND DEVELOPMENT, DESIGN, QUALIFICATION, PROCUREMENT, MANUFACTURING, CONSTRUCTION, TESTING, INSTALLATION, COMMISSIONING AND SERVICES ACTIVITIES AND MAINTENANCE FOR NUCLEAR FUEL, NEW NUCLEAR POWER PLANTS PROJECTS, EXISTING NUCLEAR PLANTS, RESEARCH REACTORS AND FOR OTHER INDUSTRIAL ACTIVITIES.

DESIGN AND MANUFACTURING OF PRESSURE EQUIPMENT & SYSTEM & COMPONENT AND EQUIPMENT, RADIOACTIVE STANDARD SOURCES AND CORE INSTRUMENTATION (E.G. IRRADIATION CAPSULE, SENSOR POCKETS), ENGINEERING SERVICES, DESIGN AND MANUFACTURING OF INSTRUMENTATION CONTROL AND ELECTRICAL SYSTEM, UNIT OUTAGE SERVICES, SYSTEMS & COMPONENTS AND EQUIPMENTS REPAIR AND REPLACEMENT, SPARE PARTS, NON DESTRUCTIVE EXAMINATION, CHEMICAL TREATMENT, AND WASTE PROCESSING, DECONTAMINATION, DISMANTLING, CONTROL AND DIAGNOSIS SYSTEMS AND CONTRIBUTION TO DIAGNOSIS, FUNCTIONAL TESTING, NUCLEAR TRAINING, OPERATION AND PROVISION OF NUCLEAR MAINTENANCE WORKSHOPS, WAREHOUSING AND PLANNING OF TRANSPORT OF RADIOACTIVE MATERIALS.

MANUFACTURING OF PARTS IN ALLOYS, SPECIAL STEEL, STAINLESS STEEL, SUPERALLOYS, NICKEL-BASED ALLOYS, TOOL STEEL, ZIRCONIUM AND ITS ALLOYS, AND OTHER REFRACTORY METALS (SUCH AS HAFNIUM, TITANIUM, NIOBIUM, TANTALUM) AND DERIVED PRODUCTS (SUCH AS $MgCl_2$, ZrO_2). MANUFACTURING ACTIVITIES INCLUDING FORGING, MOULDING, HOT SHEAR SPINNING, MACHINING, THERMAL TREATMENTS, DIMENSIONAL INSPECTION, DESTRUCTIVE AND NON DESTRUCTIVE TESTING, CHEMICAL ANALYSIS.

VERTRIEB, FORSCHUNG UND ENTWICKLUNG, DESIGN, QUALIFIZIERUNG, BESCHAFFUNG, FERTIGUNG, PRÜFUNG, ERRICHTUNGS-, INBETRIEBNAHME- UND WARTUNGS-TÄTIGKEITEN, BETREFFEND KERNBRENNSTOFF, NEUBAUPROJEKTE, BESTANDSANLAGEN, FORSCHUNGSREAKTOREN UND SONSTIGE NUKLEARE UND INDUSTRIELLE EINRICHTUNGEN.

DESIGN UND HERSTELLUNG VON DRUCKFÜHRENDEN EINRICHTUNGEN & SYSTEMEN & KOMPONENTEN UND GERÄTEN, RADIOAKTIVE PRIMÄRQUELLEN UND KERNINSTRUMENTIERUNGEN (Z.B BESTRAHLUNGSKAPSELN, TAUCHHÜLSEN) ENGINEERING DIENSTLEISTUNGEN, ENTWICKLUNG UND BEREITSTELLUNG ELEKTRO- UND LEITTECHNISCHER SYSTEME, REVISIONSEINSATZ, REPARATUR UND AUSTAUSCH VON SYSTEMEN, KOMPONENTEN UND GERÄTEN, ERSATZTEILBEREITSTELLUNG, ZERSTÖRUNGSFREIE PRÜFUNG, CHEMISCHE BEHANDLUNG UND ABFALLBEHANDLUNG, DEKONTAMINATION, RÜCKBAU, PRÜF- UND DIAGNOSETECHNIK, FUNKTIONSPRÜFUNG, NUKLEARE SCHULUNGSDIENSTLEISTUNGEN, BETRIEB UND BEREITSTELLUNG NUKLEARER INSTANDHALTUNGSWERKSTÄTTEN, LAGERUNG UND ORGANISATION DES TRANSPORTS VON RADIOAKTIVEN ELEMENTEN.

HERSTELLUNG VON TEILEN AUS LEGIERUNGEN SPEZALSTAHL, EDELSTAHL, ROSTFREIEM STAHL, SUPERLEGIERUNGEN, NICKELBASIERTEM STAHL, WERKZEUGSTAHL, ZIRKONIUM UND SEINEN LEGIERUNGEN SOWIE ANDERER WÄRMEBESTÄNDIGER METALLE (HAFNIUM, TITAN, NIOB, TANTAL) UND ABGELEITETER PRODUKTE (WIE $MgCl_2$, ZrO_2). HERSTELLUNG DURCH SCHMIEDEN, GIESSEN, WARMES FLIESSPRESSEN, SPANENDE BEARBEITUNG, WÄRMEBEHANDLUNGEN, DIMENSIONSKONTROLLE, ZERSTÖRENDE UND ZERSTÖRUNGSFREIE PRÜFUNGEN, CHEMISCHE ANALYSEN.

Certificat
Certificate

Annexe / *Appendix* **n° 2**

FRAMATOME

Liste complémentaire des sites entrant dans le périmètre de la certification :
Complementary list of locations within the certification scope:

2, rue Professeur Jean Bernard   FR-69007 LYON

27, rue de l'Industrie   FR-59573 JEUMONT

CEH ZI des Greveaux Les Guides   FR-59600 MAUBEUGE

site de JUMETIAU   186, rue Erqueulinnes   FR-59460 JEUMONT

SOMANU   ZI des Greveaux Les Guides   FR-59600 MAUBEUGE

2, rue Alphonse Poitevin   CS 4001   BP 13   FR-71380 SAINT-MARCEL

1, rue Baptiste Marcet   Centre technique MCT   FR-71200 LE CREUSOT

Atelier Forge   6, allée Jean Perrin   FR-71200 LE CREUSOT

30, boulevard de l'Industrie CS 70181   FR-71205 LE CREUSOT CEDEX

400, allée Hubert Curien   Parc Harfleur 2000   FR-71200 LE CREUSOT

1800, boulevard de l'Industrie   Parc Harfleur 2000   FR-71200 LE CREUSOT

59-65, rue Edith Cavell   FR-94400 VITRY SUR SEINE

31, rue Albert Camus   FR-49460 MONTREUIL JUIGNE

Route de Nantes   BP 21   FR-44560 PAIMBOEUF

ZI du Moulin à papier   FR-27250 RUGLES

Avenue Paul Girod   FR-73400 UGINE

291, route de l'Electrochimie   FR-38560 JARRIE

54, avenue de la déportation   Les Bérauds   ZI   BP 1114   FR-26104 ROMANS SUR ISERE

4, rue Thomas Dumorey   1, avenue de Verdun   FR-71100 CHALON SUR SAONE

Zone Industrielle de la Pillardière   FR-45600 SULLY SUR LOIRE

Annexe / *Appendix* **n° 3**

FRAMATOME

Liste complémentaire des sites entrant dans le périmètre de la certification :
Complementary list of locations within the certification scope:

5357 Industry way   US-CA94510 BENICIA

3315 Old Forest Road   US-24501-912 LYNCHBURG VA

1724, Mount Athos Road   US-24502 LYNCHBURG VA

155 Mill Ridge Road   US-24502 LYNCHBURG VA

100 East Kensinger Dr Suite 100   US-PA 16066 CRANBERRY TOWNSHIP

2101 Horn Rapids Road   US-99352 RICHLAND WA

925 Brock Road   CA-(ON) L1W PICKERING

2091 Highway 21 RR#2   CA-(ON) N2Z KINCARDINE

Framatome GmbH   Paul-Gossen-Strasse 100   DE- 91052 ERLANGEN

Advanced Nuclear Fuels GmbH   Am Seitenkanal 1   DE-49811 LINGEN

Advanced Nuclear Fuels GmbH, Am Kieswerk   DE-63791 KARLSTEIN AM MAIN

Framatome GmbH   Seligenstaedter Strasse 100   DE-63791 KARLSTEIN AM MAIN

Framatome Sweden Jungmansgatan 12 SE-211 19 MALMÖ

Framatome Spain S.L.U. Poligono Industrial Constanti,Avenida Europa esquina Calle Belgica, Isla 14, Nave 1.1-1.3 ES-43120 CONSTANTI-TARRAGONA

Framatome C/ Alvira Lasierra, 8 Bajos.   ES-50002 ZARAGOZA

Avenida de Europa, 19 Oficina C – Planta Primera. Edificio 2 P.E. Ática XIX. ES-28224 Pozuelo de Alarcón – MADRID

Framatome Controls s. r. o. Vajnorska 137 SK-83 104 BRATISLAVA

Framatome Japan KK   Redondo Building, 2F, 2-21-3 Akasaka JP-107-0052 MINATO-KU - TOKYO

Framatome I&C Korea, N°511, 187 Techno 2-ro, Yoosung, Daejeon, 34025, KOREA

Annexe / *Appendix* **n° 4**

INTERCONTROLE

Détail des activités mises en œuvre :
Details of the activities carried out:

VENTE RECHERCHE ET DEVELOPPEMENT, CONCEPTION, FABRICATION, ACTIVITES DE SERVICES POUR LES INSTALLATIONS NUCLEAIRES AINSI QUE POUR LES AUTRES SECTEURS INDUSTRIELS, ETUDE ET FABRICATION D'EQUIPEMENTS, EXAMENS NON DESTRUCTIFS.

SALES, RESEARCH AND DEVELOPMENT, DESIGN, MANUFACTURING, SERVICES ACTIVITIES FOR NUCLEAR PLANTS AND FOR OTHER INDUSTRIAL SECTORS, STUDY AND MANUFACTURING OF EQUIPMENT, NON DESTRUCTIVE EXAMINATION.

Liste complémentaire des sites entrant dans le périmètre de la certification :
Complementary list of locations within the certification scope:

ZA de la Pillardière   BP 56   FR-45600 SULLY SUR LOIRE

4, rue Thomas Dumorey   BP 71109   FR-71107 CHALON SUR SAONE CEDEX

54-56, rue d'Arcueil   FR-94150 RUNGIS

CE Cadarache   BP 21   FR-13115 SAINT PAUL LEZ DURANCE

Annexe / *Appendix* **n° 5**

FRAMATOME

Détail des activités mises en œuvre :
Details of the activities carried out:

CONCEPTION, GESTION DE PROJET ET VENTE DE SYSTEMES DE CONTRÔLE-COMMANDE, SYSTÈMES ÉLECTRIQUES, PIÈCES DE RECHANGE, TESTS FONCTIONNELS.

DESIGN, PROJECT MANAGEMENT AND SALES OF INTRUMENTATION CONTROL, ELECTRICAL SYSTEM, SPARE PARTS, FUNCTIONAL TESTING.

Liste complémentaire des sites entrant dans le périmètre de la certification :
Complementary list of locations within the certification scope:

20 Cabot Boulevard, Suite 250   US-02048 MANSFIELD

5070, rue François Cusson   Lachine   CA-H8T MONTRÉAL

Appendix / *Annexe* **n° 6**

Certificate n° / *n° de certificat*

2015/67338.15

Framatome Nuclear Services Co., Ltd

法马通核电服务有限公司

Unified Social Credit Code / *Code Crédit Social Unifié* **/ 统一社会信用代码 :**913304000916751680

Registered address – 注册地址 :
No.1 Jinhe Road, Qinshan Street, Haiyan County, Jiaxing City, Zhejiang Province, P. R. China
浙江省嘉兴市海盐县秦山街道金禾路 1 号

Details of the activities carried out :
Détail des activités mises en œuvre :

SERVICE AND SALES OF FRAMATOME GROUP NUCLEAR POWER PLANT MECHANICAL, ELECTRIC, INSTRUMENTATION & CONTROL PRODUCTS AND RELATED TOOLS, EQUIPMENT, SPARE PARTS AND DESIGN OF INSTRUMENTATION & CONTROL SYSTEM.

法马通集团核电站机械，电气，仪表控制产品以及相关工具，设备，备件的销售和服务及仪控系统的设计

Complementary list of locations within the certification scope:
Liste complémentaire des sites entrant dans le périmètre de la certification :

Room 1203, Tower 3, Han's Plaza (Dazu), Ronghua South Road, Beijing Economic and Technological Development Area, Beijing City, P. R. China
北京市北京经济技术开发区荣华南路大族广场 3 号楼 1203 室
Room 1308, No. 1277, Beijing West Road, Jing An District, Shanghai, P. R. China
上海市静安区北京西路 1277 号 1308 室

Management system assessed and found to meet the requirements of:
Système de management évalué et jugé conforme aux exigences requises par :

ISO 9001 : 2015

This appendix is valid from (year/month/day)   **2022-02-24**   until   **2023-07-04**
Cette annexe est valable à compter du (année/mois/jour)   *Jusqu'au*

Basic concept of the COMSY software platform

The COMSY software provides the platform for a number of applications and functionalities on the field of aging and plant life management. It is a software product with modular architecture, which is designed in a way where each module can be operated independently or in combination with any number of further modules. Depending on the individual scope of application the different modules can be applied as indicated in the price list.

The software program COMSY is designed to provide prognosis of degradation processes in the technical equipment of power plants. The program does not only store and manage data, but also provides a number of analytical functions. Based on the input data, it provides prognosis of e.g. critical points; predicts degradation rates and performs lifetime analysis for components. On this basis the in-service inspections and maintenance activities can be optimized.

These prognosis and trending functions are based on Framatome's internal expertise and more than 30 years of experience in the evaluation of degradation effects and numerous experimental studies. Since 1988 the software has been successfully applied in more than fifty power plant units worldwide for different reactor types (PWR, BWR, VVER, CANDU) and conventional plants. The experience feedback gained from these applications was utilized to further improve the predictive capabilities.

COMSY is a multi-user system, which allows for networking with the product. The data is securely stored in a single-source database and can be reviewed and edited by multiple workstations located in the local network. The user access to read and modify data is controlled by pre-defined user privileges. The program operates under MS Windows with a multi-user database (Microsoft SQL Server / Azure SQL or Microsoft Access). The operating personal will be trained by experienced Framatome engineers within the frame of software implementation.
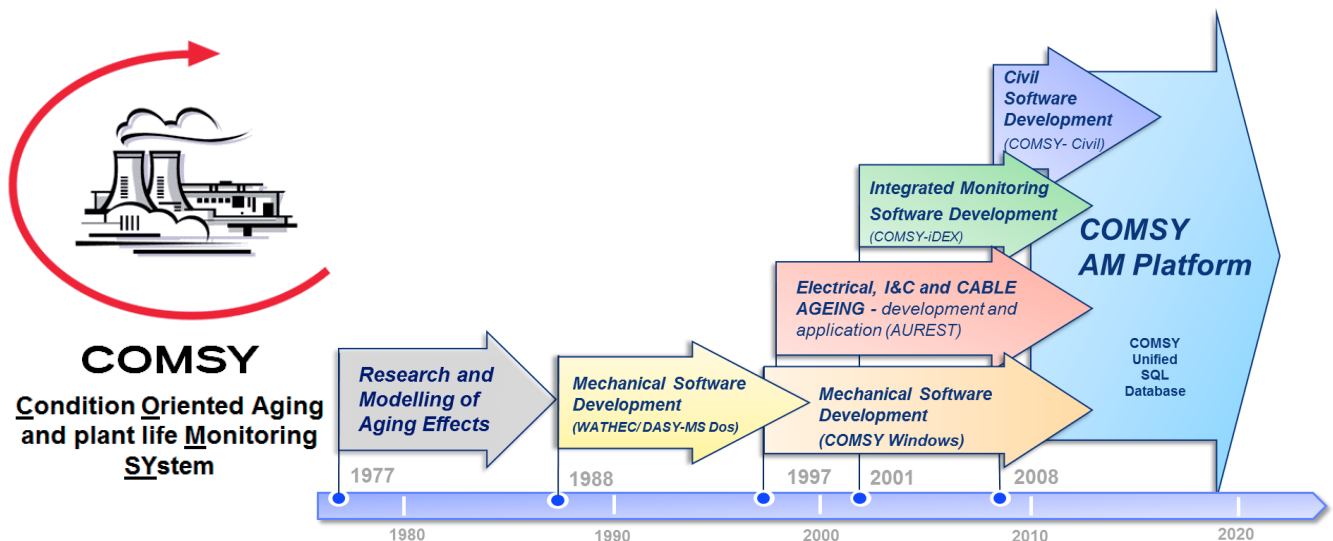
All aging-relevant component data are compiled and allocated via an integrated power plant model. Owing to existing interfaces to other software solutions and flexible import functions, COMSY is highly compatible with already existing databases in the plant. Also different unit system (e.g. SI, US) are supported by the program.

The software is running on all current Microsoft Windows® platforms, also in terminal server systems like Citrix. There are no special requirements to hardware or software to be met.

The COMSY software platform comprises functions for mechanical components, electrical equipment, civil components and a cockpit interface with Monitoring & Diagnostic applications.

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The COMSY Code for Aging and Plant Life Management
Generic Functions Covering all Disciplines
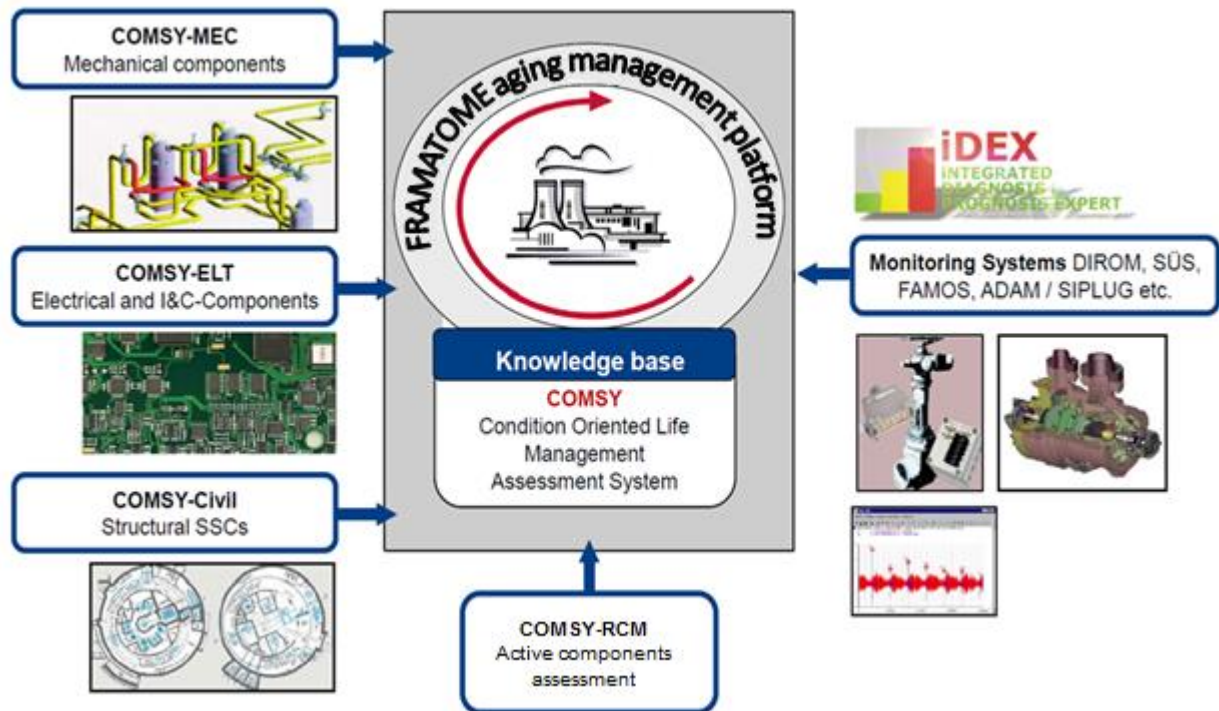
The Aging Management Platform COMSY is designed to provide degradation assessment and degradation surveillance for the technical equipment of power plants of different designs. It supports the commodity grouping process based on input data regarding design, materials, operating conditions and environmental data. On this basis the in-service inspections programs and further plant programs can be reviewed, validated and optimized.

Also, the COMSY application assists in performing a comprehensive and auditable AMR for Systems, Structures and Components (SSCs). The software based approach brings the advantage of processing a large number of components, highlighting data anomalies while providing a repeatable and transparent workflow. This also allows for easy updates and a modification or increase of the population at a later stage, in case the underlying standards, the scope of the application or source data changes.

For active components (valves, pumps, actuators, electrical motors, I&C, etc.) the strategy is based on the RCM/AP-913 approach, with the aim of optimizing the resources for maintenance in a power plant while ensuring high levels of component reliability. For critical equipment the iDEX module serves for online condition monitoring and trending.

The COMSY platform consists of modules, which are

- generically applied for all disciplines (mechanical, electrical and I&C, and civil – Modules G)

- applied for mechanical components (Modules M)

- applied for electrical and I&C equipment (Modules E)

- applied for civil structures (Module C)

- applied for online monitoring (Module iDEX)

The COMSY Functions for Data Handling and Generic Applications
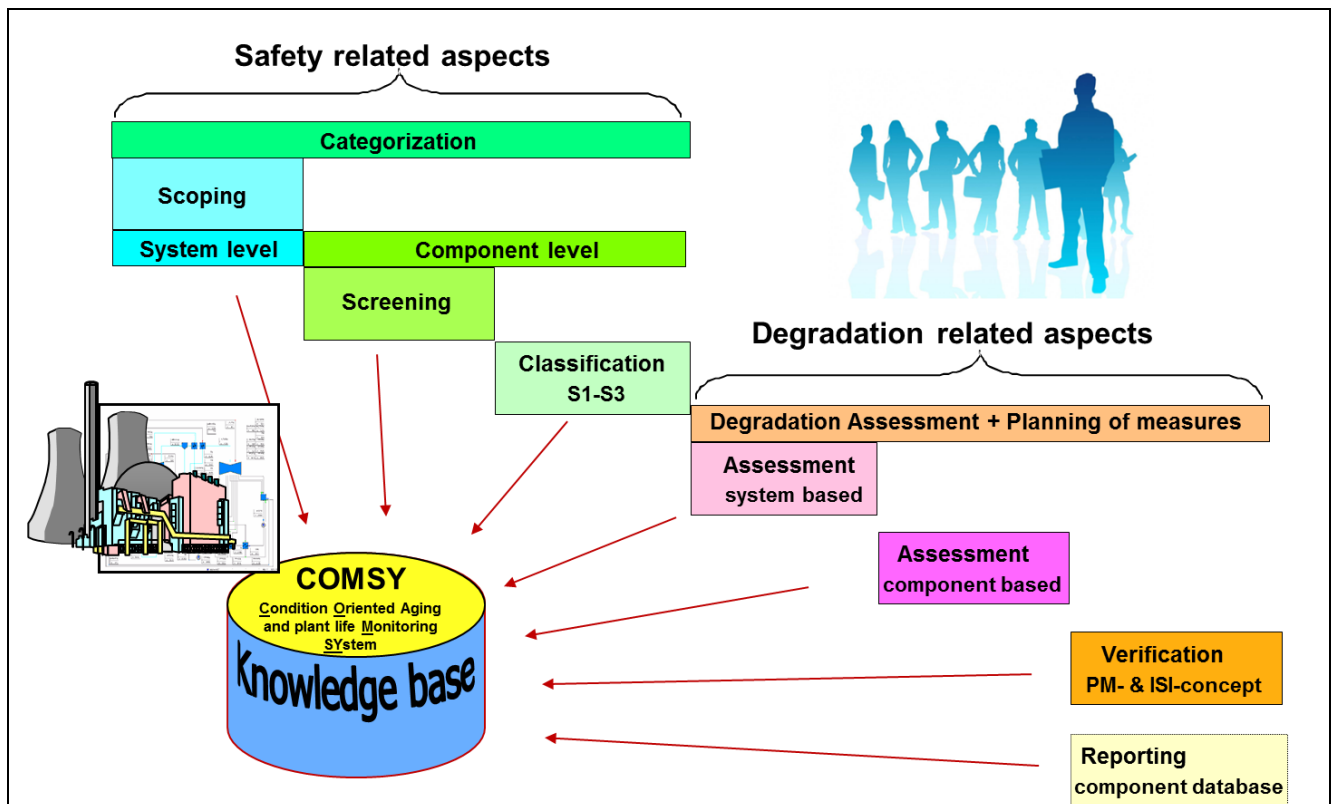
A comprehensive aging management database requires very specific data management functions for the handling of information related to systems, structures and components, considering classifications, materials, operating conditions, environmental conditions and respective commodity groups.

This is assisted by integrated libraries and calculation functions which assure that only the most relevant parameters need to be acquired, remaining values are supplemented automatically by the program. For example, the included standard material libraries that automatically adds required material properties by knowing only the material number or material type. Steam table functions help to include reasonable operating conditions and water chemistry calculations allow for automatic calculation of pH value or oxygen concentrations in steam or water phase of a liquid.

Data integrity and quality is ensured by plausibility functions, assisted by an integrated log file, a change management allowing data modification and validation for specific user privileges only and many more hidden comfort functions.

Framatome provides the following generic functional modules, of the COMSY program group, which are applicable to all disciplines:

- Module G1: COMSY user interface and basic platform for plant modeling
- Module G2: Commodity grouping
- Module G3: Integrated technical documentation management
- Module G4: Operational experience feedback program
- Module G5: Aging Management Review Reporting

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Module G1: COMSY user interface and basic platform for plant modeling

Features:

- User friendly Windows® based graphic interface
- Interactive functions for power plant modeling and parameter management
- Engineering tools and input data validation
- Comprehensive material library and standard dimension schedule
- Element addressing and visualization of data structures
- Network compatible database interface
- Managing, printing and exporting data applying MS-Office compatible formats
- Import of data from external data sources to build up a plant model quick and easy

Description:

The software product COMSY is operated under Microsoft Windows®. The software system acquires, manages and evaluates design and operating parameters relevant to service life. Plant data pertaining to individual vessel elements, piping elements and systems are stored in a "virtual plant data model".
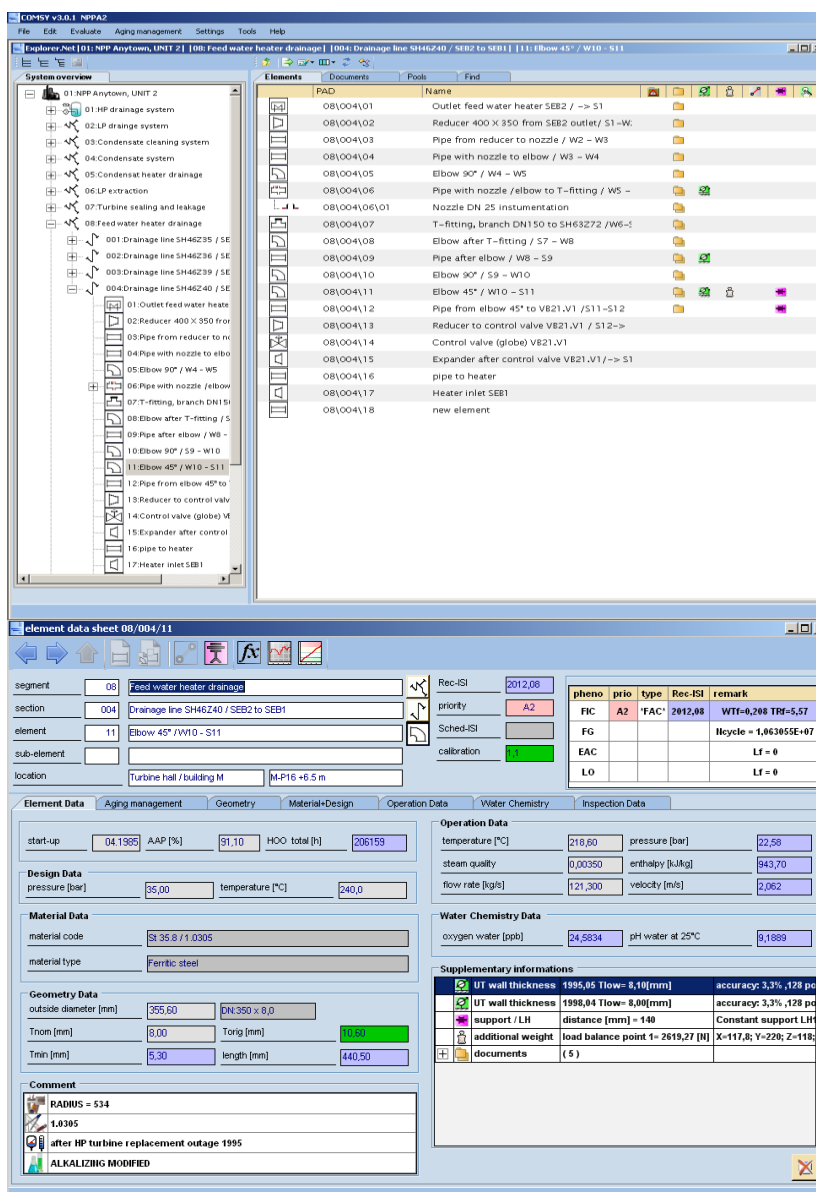
Based on these plant data, the program conducts a condition-oriented lifetime analysis for relevant degradation mechanisms. This process is supported via a smart user interface, powerful analysis functions (e.g. stress computation, thermal-hydraulic and flow analysis functions, water chemistry functions), and comprehensive material libraries for ASME, AFNOR, DIN, JIS and GOST standard. User interface for modelling operating time dependent thermal-hydraulic operation conditions, including a computerized steam table, a computerized flow chart and engineering tools for flow computations. For data management it provides forms and dialogs for modeling operation time dependent water chemical conditions, including engineering tools for computing hot and cold pH-values for given alkalizing concentrations and analytical functions for volatility computations.

Plausibility check functions serve to provide consistent input data.

The system is designed to be operated in a computer network with a multi-user environment or on a local computer. For printing, importing and exporting data, MS-Office compatible formats are used.

![framatome logo]

Module G2: Commodity Grouping
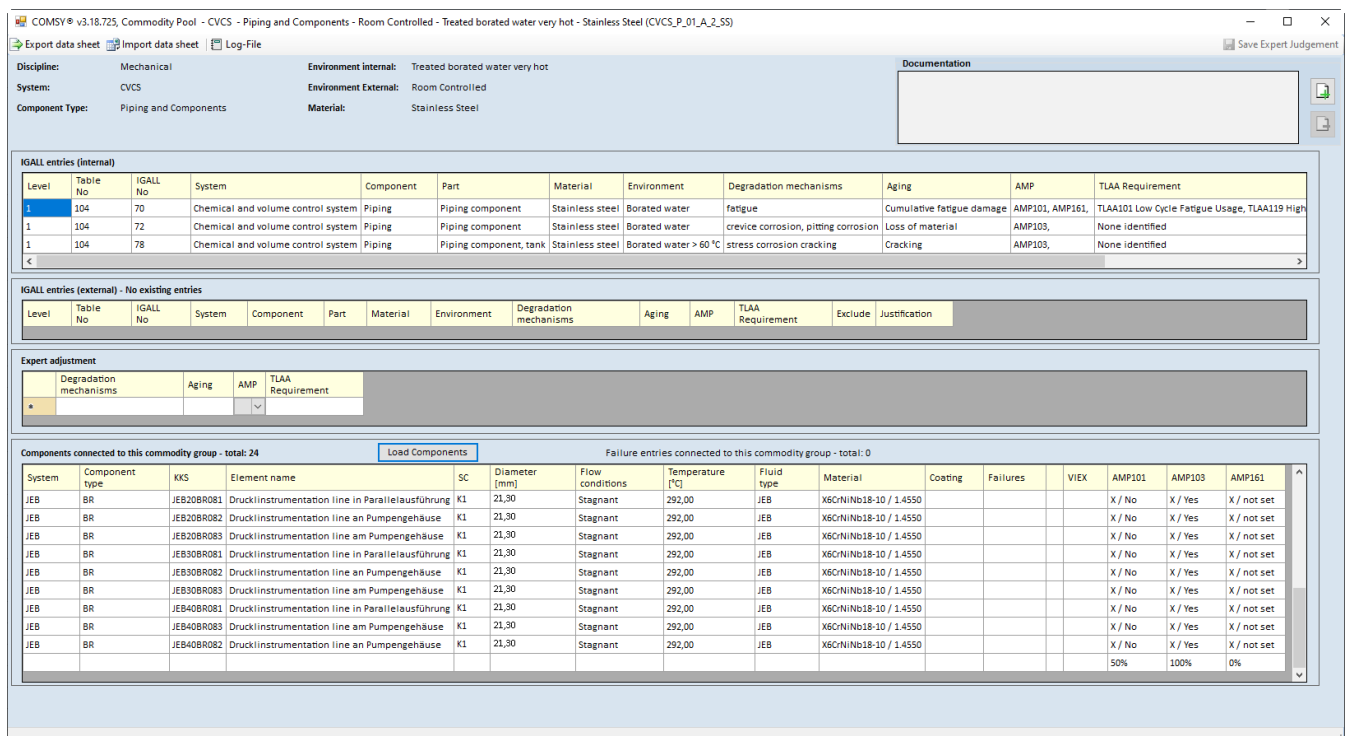
Features:
- Commodity grouping according to IGALL or GALL rules
- Indication of recommended AMPs and AMP requirements
- Management of plant program activities
- Validation of inspection and maintenance activities

Description:

Next to the power plant modeling functions as described in module G1, COMSY import functions flexibly provide access to existing databases / data tables and converts respective data into the required formats. The COMSY data structure is based on a comprehensive data processing system for 'SSCs' (Systems, Structures and Components) of a plant. In case of mechanical components, a subdivision in individual systems, lines and piping elements or vessel components is carried out. For electrical equipment and I&C an allocation into functional equipment e.g. valve operating gear to the switchboard can be generated. For civil structures a building depending break down into civil clusters e.g. groundings, walls, lifting equipment, etc. is performed.

Framatome provides the service to import bulk amounts of components, examinations or inspection programs using existing data from e.g. Maximo, Asset Suite, SAP, BFS or other plant management systems with the above mentioned functions in little time. This minimizes the effort for data modeling and safes man years of work. Integrated plausibility checks assure data integrity and identify incorrect or missing aging parameters.

Commodity group example for IGALL application

After the plant model is established, the COMSY software supports the formation of commodity groups according to the pre-defined structure of the IGALL/GALL Master Table without any further effort. The programme is able to link SSCs stored in the Aging Management Database with categories, commodity groups and sub-commodity groups. For these commodity groups it indicates degradation mechanisms, aging effects and addresses AMPs with recommended actions to manage aging.

For each SSC as a member of the respective commodity group the existing in-service inspections programmes and maintenance activities are validated or gaps are identified. Furthermore, commodity groups are checked for adequate preventive programs, which are linked to each commodity and validated against the generic attributes of an AMP and their requirements.

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Module G3: Integrated technical documentation management

Features:
- Documentation functions for linking reports, drawings, pictures, movies etc.
- All common Windows documents formats are supported
- Modeling of document relations using pool structures

Description:

A major requirement on plant management software is easy and clear access to the archived data, particularly with a focus on preventing any loss of technical knowledge in the event of personnel replacement in the plants. COMSY offers the possibility of systematic compilation of digitized documentation for describing the current condition of the plant or of individual components or structures. This way the documentation function can be used as "living documentation" in everyday applications.
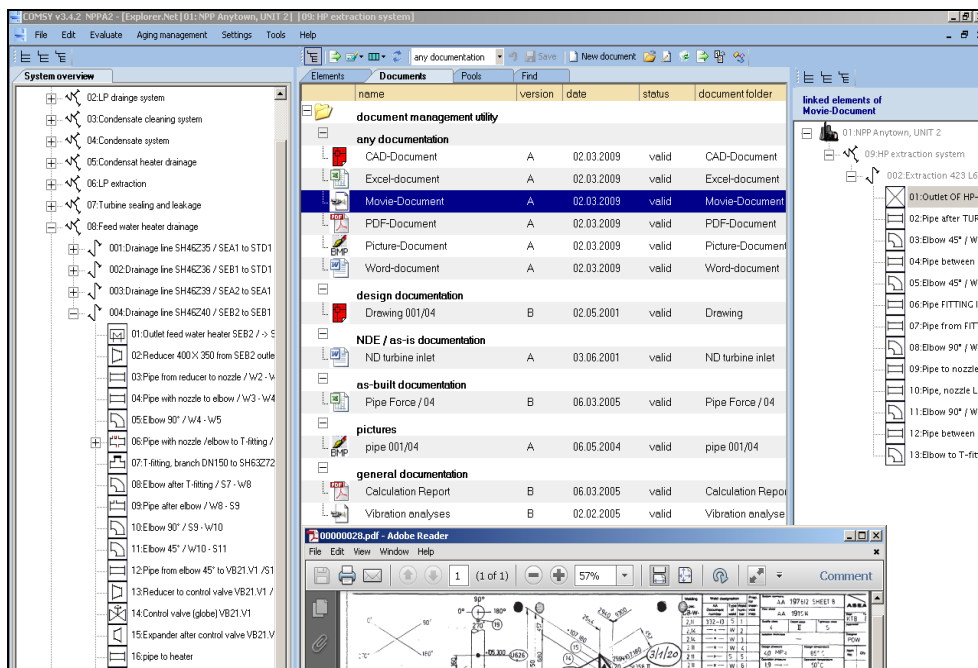
User Interface for the Technical Documentation Management

The integrated flexible technical documentation management functionality provides the option to interactively associate detailed documents, such as design drawings, P&IDs, isometrics, maintenance manuals, reports from the time of plant construction or change procedures as well as memos, comments, pictures, inspection results or videos. The integrated document management utility serves to assign different 'documentation pools' with corresponding components or systems included with the plant data model.

Documents can be furthermore assigned to different (predefined or user-defined) document types, e.g. manufacturing, design drawing, inspection, maintenance, etc). Each document (or document package) can be linked with one component, or component groupings, e.g. systems or sub-systems.

The pool-structure of the document management makes it easy to locate relevant documents just by knowing the respective component or system. Additionally an integrated powerful search function supports the inquiry for documents or components in the database.

The function manages and interactively displays most commonly used formats in the Windows environment for written reports, spreadsheet tables, scanned drawings, color pictures and CAD drawings. Documents can be also linked to existing document managers, e.g. SAP or Lotus Notes, which ensures using the latest versions.

Having all relevant and up-to-date documents available for every component greatly facilitates the typical processes in the Aging Management like planning of inspection locations, enhancing component information or checking the validity of parameters.
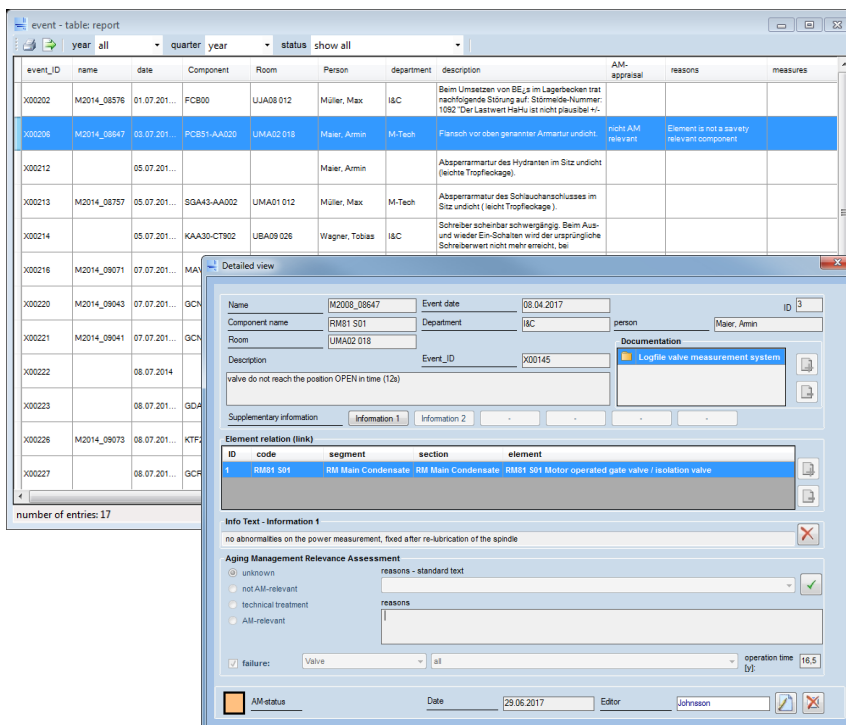
Module G4: Operational experience feedback program

Features:
- Recording of reports describing events in national and international NPPs
- Assessment in respect to causes and aging relevance
- Analysis of transferability based on the virtual plant data model.

Description:
A key contributor to enhancing plant safety is the ability to learn from operational experience. Within the scope of the aging management program this addresses the analysis of transferability of more or less significant events occurring nationally or internationally, so that the repeated occurrence of similar events can be prevented. The value of an effective operating experience program is generally well recognized. Within the scope of the aging management program reports concerning aging relevant events from other sources and from the own plant need to be analyzed, and corrective actions may need to be implemented in case of systematic events.

User Interface for the handling of operational experience reports

The integrated function for the handling of operational experience feedback reports provides the option to systematically manage, assess, filter and categorize reports on events occurring in the nuclear power industry, in sister plants or the plant itself. In case aging or reliability relevant events occur, a transferability check is carried out by comparing relevant parameters from the degradation event with plant specific component data stored in the data base. If respective components are identified, a link is created with the corresponding components or systems. This supports the statistical evaluation of event frequencies and the management of corrective actions which may need to be implemented.

The functionality provides the basis for further evaluating the operational behavior of plant components by systematically recording failures experienced with certain components by utilizing failure mode classifications (FMEA). The operational experience feedback information can be used for statistical evaluations and probabilistic approaches to determine updated MTBF (mean time between failures) for the components considered (see module M9) and to respectively update the information stored in the device library for further optimizing maintenance scope and intervals on a plant wide basis

The operational experience feedback function utilizes existing data from the application of other modules. The information involved with the process can be exported and utilized for the documentation of aging management activities, e.g. for periodic aging management status reports.

Also import functions are available to establish interfaces and easily transfer operating feedback from external sources like WANO, VGB, SAP, BFS or other platforms.

Module G5: Aging Management Review Reporting

Features:
- Management of inspection procedures
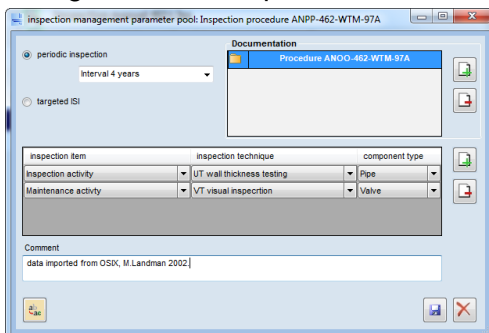- Component aging status reporting and full plant status export

Description:

All aging management rules call for a comprehensive approach, requiring the systematic collection of various aging and safety relevant data on a plant-wide basis. The plant data collected during the scoping and screening process needs to be serviced and periodically evaluated.

The process of aging management (AM) has the objective to monitor and control degradation effects which may compromise safety functions of the plant. Steps are:

- Identification of possible degradation mechanisms for safety relevant Systems, Structures and Components (SSC)

- Ensure, that testing and maintenance programs sufficiently provide preventive measures to control degradation effects

To support this process COMSY offers an Inspection and Maintenance Management pool where all periodic procedures are stored. Using the pool manager or imports all aging relevant procedures can be simply assigned to the respective elements.
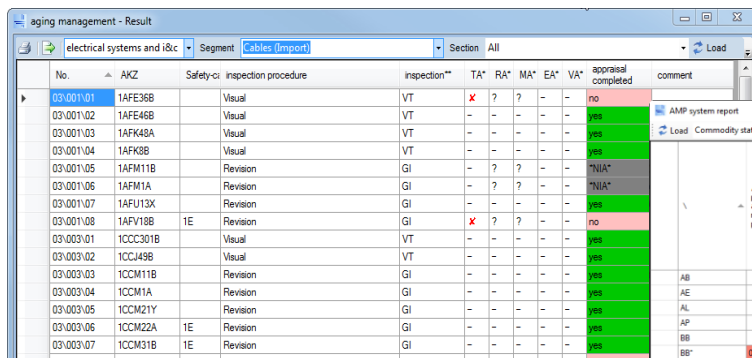
The evaluation of degradation effects utilizes existing data from the application of modules M2 to M5 for mechanical, E1 and E2 for electrical application and C1 for civil applications. On a component level the Aging Report summarizes the degradation effects versus the inspection program whereas on plant level the full report computes the plant status.
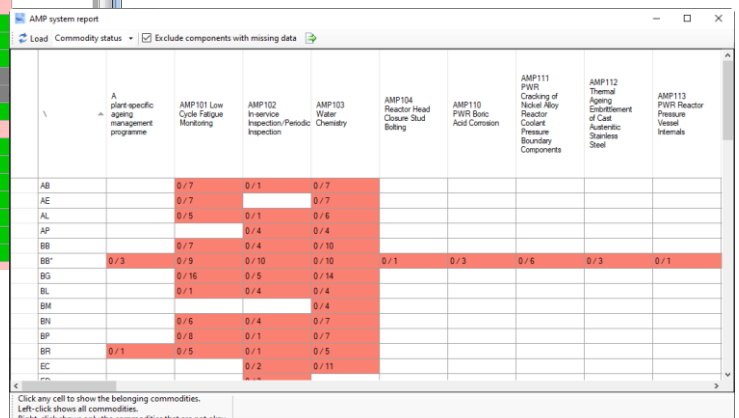
This information is used to cross-check the existing inspection practices with inspection recommendations resulting from the degradation assessment.

The Aging Management Reporting functions summarize the results of the Aging Management Review and the IGALL/GALL commodity grouping results. That includes the cross-check between degradation assessment results and the inspection management procedures. This allows to demonstrate the effectiveness of the plants inspection and maintenance program.

**Examples for Aging Management Report
for electrical components(left)
and AMP System Report (right)**

The COMSY Code for Aging and Plant Life Management Mechanical Components

MATERIAL LIBRARIES
- Standard material library
- As built material library

PLANT DATA MODEL

INSPECTION MANAGMENT
- Inspection planning
- Examination record management and evaluation
- Risk informed assessment

DEGRADATION MECHANISMS
- General Corrosion
- Microbiological Corrosion
- Localized Corrosion
- Stress Corrosion Cracking
- Fatigue
- Corrosion Fatigue
- Flow Induced Corrosion

COMSY
Condition Oriented Aging and plant life Monitoring SYstem

CALCULATION MODULES
- Water chemistry cycle analysis
- Stress analysis
- Fluid dynamical calculations
- Thermal hydraulic calculations
- Fracture mechanical analysis

DOCUMENT MANAGEMENT SYSTEM

Framatome provides the software tool COMSY to support a knowledge-based aging and plant life management strategy for mechanical components. The tool provides a comprehensive documentation function and allows for pinpointing system areas susceptible to specific degradation mechanisms. It uses analytical and semi-empirical models to predict degradation, contains a comprehensive material library and manages the results of inspections. Furthermore, it allows risk- and condition-oriented service life assessment for components and piping systems. The results of inspections already performed on specific plant elements are automatically used to optimize further lifetime predictions over the equipment service life (trending).

Framatome provides the following functional modules of the COMSY program group:

- Module M1: Plant-wide analysis and water chemistry cycle calculation
- Module M2: Degradation prediction models and evaluation functions for flow-induced corrosion mechanisms (FIC)
- Module M3: Degradation prediction models for material fatigue and associated load cycle data management
- Module M4: Degradation prediction models for untreated water phenomena
- Module M5: Degradation sensitivity assessment functions
- Module M6: Risk informed prioritization of inspection and maintenance activities
- Module M7: Examination data management
- Module M8: As-built material data library
- Module M9: Active components reliability
- Module M10: Simplified degradation assessment for license renewal applications

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Module M1: Plant-wide analysis and water chemistry cycle calculation

Features:

- Tools for modeling the plants system design based on heat balance diagram data
- Analysis routines for computation of local oxygen concentrations, alkalizing concentrations (all common agents supported) and pH values based on a known injection rate
- Evaluation functions indicating system-related water chemistry conditions for the water- and steam phase at any cycle location modeled
- Function for determining degradation sensitivity for respective systems and sub-systems

Description:

The COMSY BOP (Balance Of Plant) module was developed to provide a systematic screening procedure reliably identifying system areas, which may be subject to specific types of degradation. In order to determine these areas in question, the water chemical conditions in each system and sub-system in respect to e.g. pH-values or oxygen concentrations are of major importance. For this reason, a 'water chemistry cycle calculation' was developed. Based on the known conditions at the oxygen or alkalizing agent injection area or at a water chemistry sampling location this function is capable to compute the distribution of agents throughout the system interconnections.
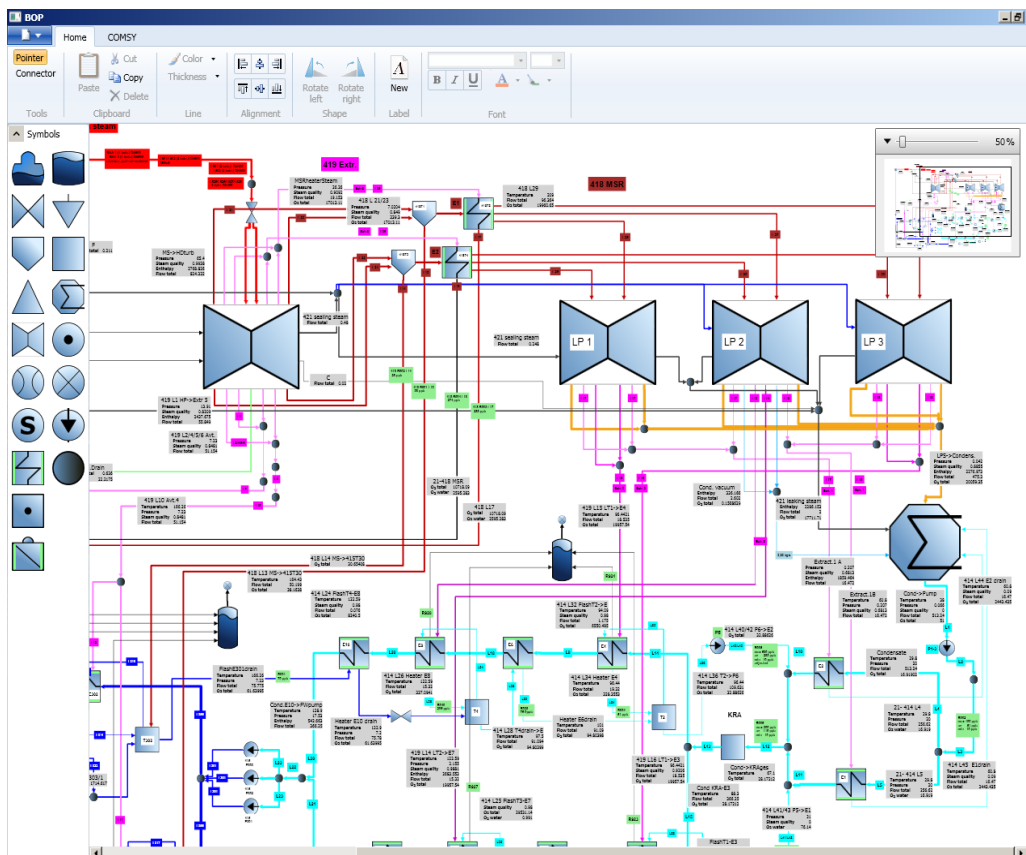
During the application process the heat balance diagram of the power plant is modeled, including system parameters for each relevant system area. Based on this model an analysis of the water chemistry cycle is performed, considering associated thermo-hydraulic parameters. Taking into consideration the typical materials used in each case, the system areas are now studied with respect to the degradation potential imposed by e.g. flow-accelerated corrosion and further degradation mechanisms.

The results of this study provide a matrix indicating for which power plant system a degradation potential exists. Based on that, systems requiring further assessment are identified. For these systems a detailed analysis function can be applied. Based on our experience up to 80% of the systems can be neglected using this approach which allows focusing on vulnerable area by moving inspection locations and/ or reducing them.

This function is furthermore especially valuable for strategic considerations, design optimizations and for studying the effect of e.g. power uprates or changes in water chemical conditioning.
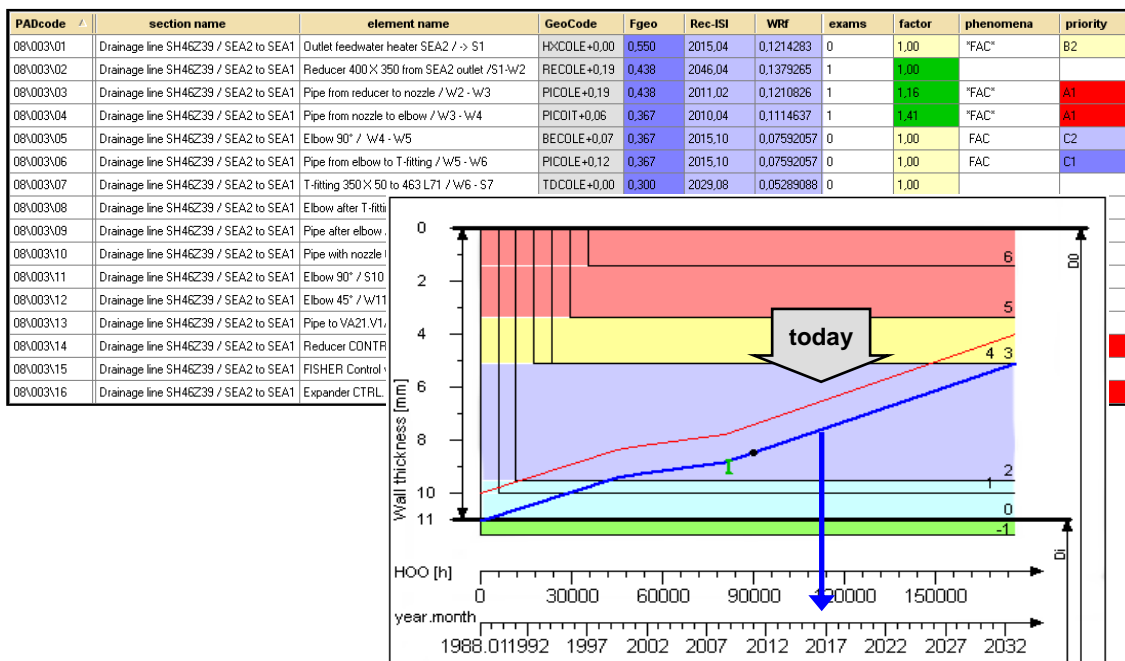
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Module M2: Degradation prediction models and evaluation functions for flow-induced corrosion mechanisms (FIC)

Lifetime prediction features:

- Flow-accelerated corrosion (FAC) or Erosion-corrosion
- Cavitation erosion (CA)
- Liquid droplet impingement erosion (LDI).

Description:

Flow-induced corrosion causes wall thinning in piping, vessels, and equipment made from carbon steel and low alloy steel. FIC occurs under certain conditions of thermal-hydraulics, water chemistry and piping/component geometry for specific material types. These conditions are commonly found in high-energy piping. Consequently, FIC has become a major issue, particularly for nuclear plants. Piping ruptures caused by flow-accelerated corrosion are a serious issue, as they may occur spontaneously without leak-before-break indication. Next to safety related problems as a result of pipe ruptures and leaks, erosion corrosion is source of iron ingress, causing the degradation of steam generators and heat exchangers.

PADcode	section name	element name	GeoCode	Fgeo	Rec-ISI	WRf	exams	factor	phenomena	priority
08\003\01	Drainage line SH46Z39 / SEA2 to SEA1	Outlet feedwater heater SEA2 / -> S1	HXCOLE+0,00	0,550	2015,04	0,1214283	0	1,00	"FAC"	B2
08\003\02	Drainage line SH46Z39 / SEA2 to SEA1	Reducer 400 X 350 from SEA2 outlet /S1-W2	RECOLE+0,19	0,438	2046,04	0,1379265	1	1,00		
08\003\03	Drainage line SH46Z39 / SEA2 to SEA1	Pipe from reducer to nozzle / W2 - W3	PICOLE+0,19	0,438	2011,02	0,1210826	1	1,16	"FAC"	A1
08\003\04	Drainage line SH46Z39 / SEA2 to SEA1	Pipe from nozzle to elbow / W3 - W4	PICOIT+0,06	0,367	2010,04	0,1114637	1	1,41	"FAC"	A1
08\003\05	Drainage line SH46Z39 / SEA2 to SEA1	Elbow 90° / W4 - W5	BECOLE+0,07	0,367	2015,10	0,07592057	0	1,00	FAC	C2
08\003\06	Drainage line SH46Z39 / SEA2 to SEA1	Pipe from elbow to T-fitting / W5 - W6	PICOLE+0,12	0,367	2015,10	0,07592057	0	1,00	FAC	C1
08\003\07	Drainage line SH46Z39 / SEA2 to SEA1	T-fitting 350 X 50 to 463 L71 / W6 - S7	TDCOLE+0,00	0,300	2029,08	0,05289088	0	1,00		
08\003\08	Drainage line SH46Z39 / SEA2 to SEA1	Elbow after T-fitti								
08\003\09	Drainage line SH46Z39 / SEA2 to SEA1	Pipe after elbow .								
08\003\10	Drainage line SH46Z39 / SEA2 to SEA1	Pipe with nozzle								
08\003\11	Drainage line SH46Z39 / SEA2 to SEA1	Elbow 90° / S10								
08\003\12	Drainage line SH46Z39 / SEA2 to SEA1	Elbow 45° / W11								
08\003\13	Drainage line SH46Z39 / SEA2 to SEA1	Pipe to VA21.V1.								
08\003\14	Drainage line SH46Z39 / SEA2 to SEA1	Reducer CONTR								
08\003\15	Drainage line SH46Z39 / SEA2 to SEA1	FISHER Control								
08\003\16	Drainage line SH46Z39 / SEA2 to SEA1	Expander CTRL.								

Service life predictions in respect to flow-accelerated corrosion are one of the key functions of the COMSY system. The degradation model engaged in this process has been optimized in several steps to reliably provide conservative predictions within an acceptable tolerance bandwidth. Next to flow-accelerated corrosion is considers liquid droplet impingement effects, cavitation erosion and the superposition of respective effects. The prediction accuracy has been proven in international benchmarks and plant feedback for all common power plant types.

Based on the predicted service life, components are prioritized for examination programs and condition-oriented inspection plans are prepared. The results of component examinations (see module M6) are fed back into the program system and are used for further optimization of service life predictions over the life cycle of the component.

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Module M3: Degradation prediction models for material fatigue and associated load cycle data management

Lifetime prediction features:

- Thermal transient fatigue
- Environmental assisted fatigue (EAF)
- Flow-induced thermal cycling fatigue
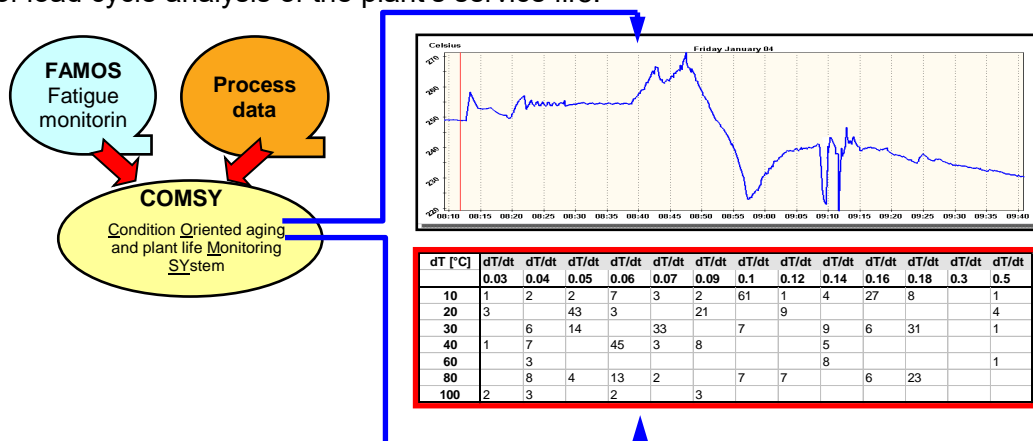- Flow-induced thermal stratification fatigue.

Description:

Fatigue is a dynamic phenomenon that initiates small (micro) cracks in the material or component and causes them to grow into large (macro) cracks. This may result in the sudden fracture of a component after a period of cyclic loading causing progressive deterioration of the material strength.

Fatigue phenomena commonly experienced in power plants are induced by thermal transients in piping system (e.g. start- and shut-down procedures), by local temperature oscillations in branches (thermal cycling) and by local effects like thermal stratification. Environmentally assisted fatigue is a phenomenon which leads to reduced fatigue life and increased crack growth. EAF stressors are oxygen content in the fluid, temperature, strain rate etc. Fatigue assessment functions have been adopted to consider the impact of EAF stressors.
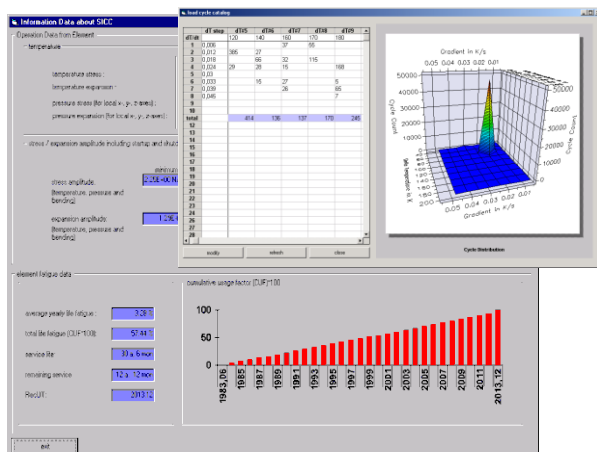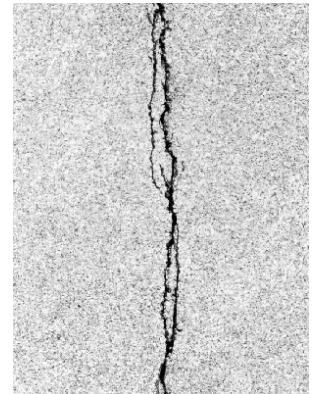
COMSY utilizes formulations according to TRD301, AD-S2, KTA3211.2, and ASME Sec.III to determine the fatigue sensitivity of piping components. For each element the allowable number of cold starts is computed. If a specification regarding the load cycles actually experienced exists, the usage factor and the respective remaining fatigue life can be computed. Corrosion fatigue is specifically considered by engaging environmental factors according to NUREC CR-6909. Additional thermal hydraulic models serve to identify locations sensitive for flow-induced thermal cycling and stratification. The calculation of fatigue usage factors utilizes the given modeling structure for piping as described for module G1 in combination with inspection experience feedback, as described for module M7.

COMSY furthermore provides the functionality to import long-term temperature instrumentation readings from the FAMOS fatigue monitoring system and/or from process data acquisition systems for the purpose of load cycle analysis of the plant's service life.

dT [°C]	dT/dt 0.03	dT/dt 0.04	dT/dt 0.05	dT/dt 0.06	dT/dt 0.07	dT/dt 0.09	dT/dt 0.1	dT/dt 0.12	dT/dt 0.14	dT/dt 0.16	dT/dt 0.18	dT/dt 0.3	dT/dt 0.5
10	1	2	2	7	3	2	61	1	4	27	8		1
20	3		43	3		21		9					4
30		6	14		33		7		9	6	31		1
40	1	7		45	3	8			5				
60		3							8				1
80		8	4	13	2		7	7		6	23		
100	2	3		2		3							

Module M4: Degradation prediction models for untreated water phenomena

Degradation assessment features (in addition to degradation mechanisms stated in Modules M2+M3):

- General corrosion, shallow pitting
- Tuberculation
- Pitting

Description:

The service water piping is a critical part of the technical infrastructure of power plants. Service water piping mainly consists of carbon steel piping operated at comparatively low-temperatures and low-pressure. The primary degradation mechanisms affecting these systems are General Corrosion, Pitting and Tuberculation.

General corrosion affects many different nuclear components in a wide range of environmental conditions. It is the most common form of corrosion and represents the greatest destruction of metal on a tonnage basis. The result is wall thinning causing loss of material. Consequently, the metallic surface becomes rough and possibly frosted in appearance.
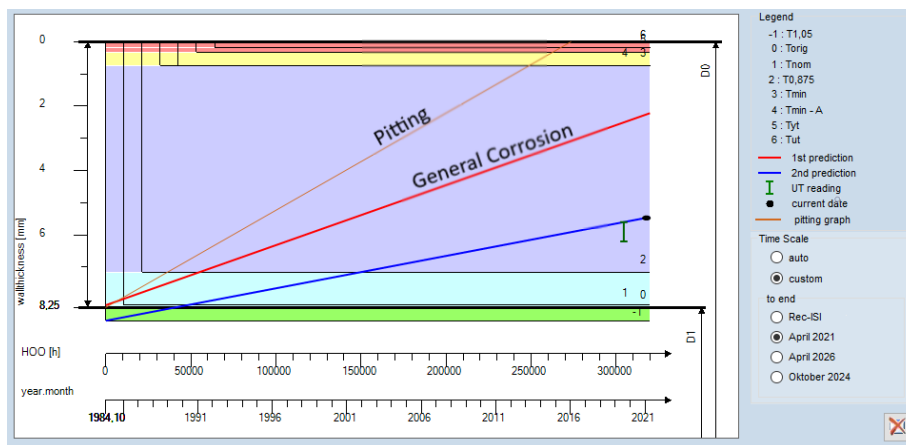
Pitting corrosion is a type of local corrosion that proceeds in a very limited area. It causes failures of carbon steel pipes and other process equipment. Pitting corrosion is identified by the shape of the pits, of which the depth is generally larger than the diameter.

Tuberculation is a type of corrosion frequently found in service water piping in conjunction with general corrosion and pitting. It is an oxygen-driven form of corrosion that results in iron oxide precipitation. In other words, the formation or tubercles, which are depositions of ferrous oxide from the water. Tubercles can choke pipes, leading to diminished flow and increased energy consumption for pumps. Furthermore, in specific cases also material loss forming shallows within the tubercle can occur and weaken the base material. Modeling of general corrosion, pitting corrosion and tuberculation helps to estimate the remaining service life of assets as well as the frequency of monitoring, inspection and maintenance.

The corrosion rate in aqueous environments is calculated based on data for material properties, thermal hydraulic conditions and water chemical aspects. It considers the specific material properties of the component, the operating mode (continuous, intermittent, stagnant), the given environmental conditions (e.g. temperatures, flow conditions, oxygen concentrations, etc.) and specifics like coatings on the inner surface.

If available, the inspection experience is considered and a calibration of the degradation rate is carried out to resemble the actual situation in the system concerned. In addition, analysis results for flow induced corrosion and fatigue calculations (Modules M2+M3) are utilized. Based on the above results, components are categorized in respect to degradation sensitivity groups.

The main objective is to generate a dependable ranking of components or locations to be inspected. Based on degradation prognosis in combination with inspection feedback a trending / monitoring of degradation effects is carried out and critical components are highlighted.

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Module M5: Degradation Sensitivity Assessment Functions

Degradation assessment features (in addition to degradation mechanisms stated in Modules M2-M4):
- Microbiologically induced corrosion (MIC)
- Stress induced corrosion cracking (IGSCC, TGSCC, PWSCC)
- Pitting for high alloyed steels, Crevice corrosion

Description:

The process of Aging Management has the objective to monitor and control degradation effects which may compromise the integrity of components. Target is the identification of possible degradation mechanisms and to ensure that adequate inspection programs are applied.

The degradation assessment process requires the knowledge of component design aspects, material data, operating conditions and chemical data. The main objective is to generate a dependable ranking of components or locations to be inspected based on the degradation potential evaluations.

For this purpose, the function assesses the likelihood of the occurrence of degradation mechanisms based on the given component data in each case. This includes the evaluation of materials applied (assisted by the integrated standard material library which includes properties for more than 2000 internationally used steels), the water chemical situation, thermal hydraulic operating conditions and the individual geometry. Furthermore, the inspection experience is considered, if available. In addition, analysis results for flow induced corrosion and fatigue calculations (Modules M2+M3) are utilized. Based on the above results, components are categorized in respect to degradation sensitivity groups. For this activity COMSY provides a comprehensive user interface, which efficiently supports the degradation assessment process.

The integrated degradation assessment function serves to systematically evaluate the vulnerability of SSCs. During the assessment process the program considers the specific material properties of the component for the given environmental conditions (e.g. temperatures, flow conditions, oxygen concentrations, operating modes). It also considers weld materials; weld joint geometry, possible coatings, if the respective data is available.

Depending on the degradation sensitivity determined, a suggested inspection deadline is provided by COMSY.

For each degradation mechanism considered, a statement is provided indicating key causes of sensitivity.

User Interface for Degradation Assessment

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Module M6: Risk informed prioritization of inspection and maintenance activities

Risk informed prioritization of inspection and maintenance activities are based on degradation assessment results generated by Modules M2 to M5: The function includes

- Functions to manage risk-related parameters
- RI-Methodology related functions and visualization
- Integrated quantitative assessment of failure risk
- User interface for selecting and managing inspections

Description:

The process of the risk-informed inspection planning integrates service experience, the knowledge of plant design aspects, information on relevant degradation mechanisms and risk insights. The main objective is to generate a dependable ranking of components or locations to be inspected based on the insights from the consequence assessment and degradation potential evaluations.

For this purpose, the function manages risk-related parameters and assesses the likelihood of the occurrence of degradation mechanisms based on the given degradation models (Modules M2 to M5).

The RI ISI methodology for nuclear safety significant components uses the conditional core damage probability (CCDP) and the conditional large early release probability (CLERP) as consequence measure. In this approach it is considered that the degradation mechanism evaluation defines the 'frequency of piping failure occurrence'. The CCDP/CLERP values define the plant response to that piping failure.

In case of non-nuclear safety significant components, the procedure for defining the measure for failure consequence in COMSY is left open, hence also existing safety classes, inspection groups or the automatically assessed consequences of a pipe break can be used as a measure.
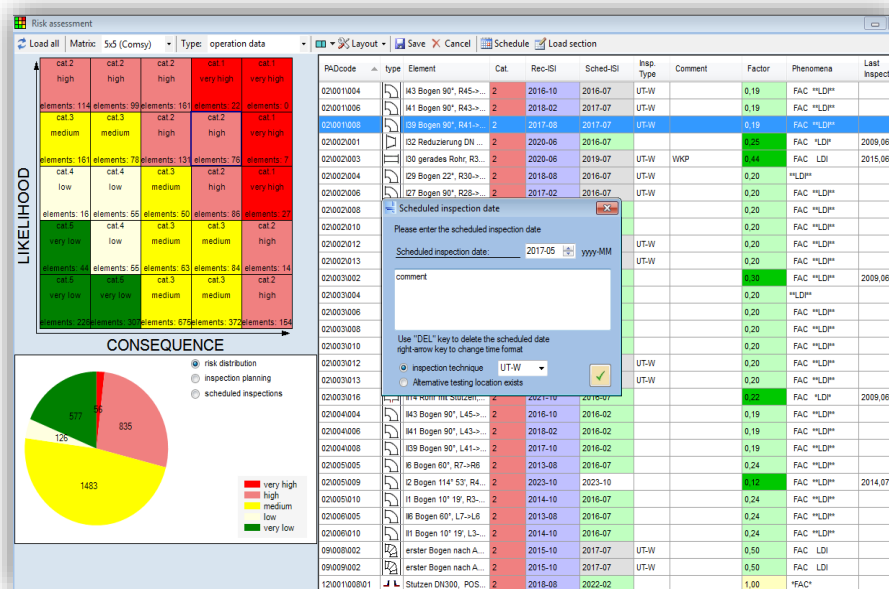
For this activity COMSY provides a comprehensive user interface which efficiently supports the risk-informed assessment process

The integrated ranking function serves to focus inspection activities on safety relevant elements with an existing degradation potential. The computer guided ISI selection procedure supports the generation of an ISI schedule and the selection of appropriate inspection techniques for the respective item. In addition, it allows for engineering judgment interactions.

User Interface for RI-ISI Applications

The COMSY software provides integrated RI assessment functions with quantitative failure risk assessment based on degradation prognosis, which makes the RI-ISI process highly effective. Major savings can be achieved especially for the RI-ISI follow-up programs, as the RI-ISI programs must be regularly updated.

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Module M7: Examination data management

Features:

- Examination data input forms for examination records (UT, RT, VT, PT, etc.)
- Visualization functions to support the evaluation of UT examination readings
- Interactive evaluation of wall thickness readings (blanket method)
- Calibration functions to analyze the actual state of piping elements versus the predicted state
- Functions for extrapolating key examination results
- Examination data import interfaces
- Visual inspection data management.

Description:

This module handles the storage, administration, evaluation and documentation of NDT examination results. Examination data are utilized for further lifetime predictions with increased prediction accuracy.

The examination and inspection results are linked to the examined component for documentation of the as-is condition at that specific time in the operating history of the plant, and are integrated into the virtual power plant data model.
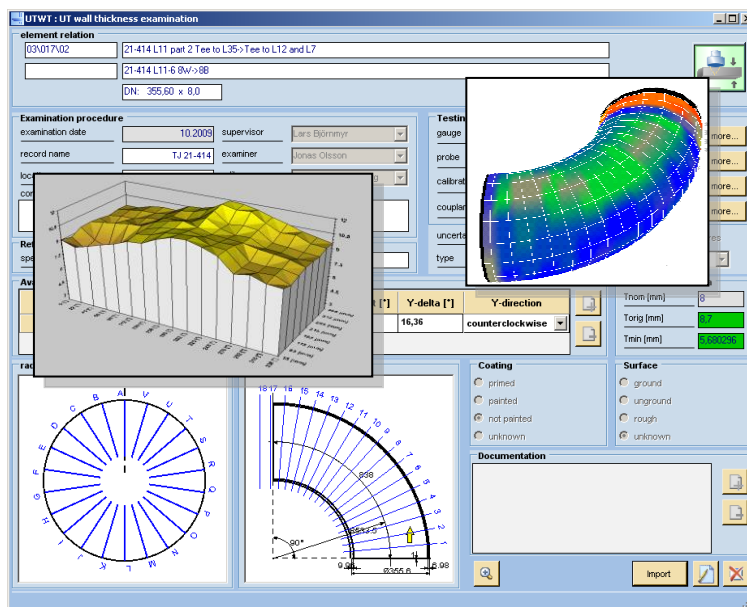
Evaluation of component examinations

The evaluation of component examinations is supported by e.g. interactive analysis functions which greatly simplify the geometry-dependent evaluation of measurement results, among other things. A calibration function supports the comparison of the as-measured condition with the predicted progression of the degradation, while making allowance for measurement tolerances. The results of this comparison are used in order to improve the accuracy of future service life predictions.

This process ensures that experience gained from evaluation of examination data will be fed back into the process of analytical service life predictions. Examination data resulting from in-service inspections are thus consistently used in the preparation of a reliable database which is kept continually up to date.

This process increases the significance of examination results and makes it possible to provide a comprehensive assessment of the as-is condition of components and systems.

The functionality consists of different data sheets for specific inspection types, tables for measurement readings and semi-automated evaluation options. Visualization options include the representation of the component inner surface in 2D and 3D and component geometry with a color coded outer surface. Measurement data import functions are provided for the following data formats:

- Krautkramer DME DL data logger
- Panametrics Series 26
- Standard ACCESS database
- EXCEL data tables.

For the documentation of visual inspection results, the program is capable to store most commonly applied digital picture formats.

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Module M8: As-Built Material Data Library

Features:

- Material as-built documentation for base material, welds and cladding
- Acceptance data regarding chemical analysis and mechanical characteristics
- Annealing and heat treatment
- Manufacturing process specification

Description:

The knowledge of specific material properties of components is valuable in the detailed evaluation of specific degradation mechanisms (e.g. stress corrosion cracking). For this purpose, COMSY software optimally includes specific as-build material documentation functions for major components to manage data from an "as-built" material library. This includes the material acceptance documentation prepared e.g. at the time the material or component was manufactured. This documentation includes the following information:

- Material-relevant information on components about the manufacturing process (e.g. manufacturer, semi-finished product form dimensions, heat treatment steps),
- Manufacturing and acceptance data regarding chemical analysis and mechanical characteristics (strength, toughness) for base material heats, welds, weld overlay cladding and buttering, as well as for production weld test coupons and welding material batches
- tensile data, fracture toughness properties, as well as Pellini testing, A, Z, Kv = f(T), Kj = f(T) (for Master Curve),
- Trending of material properties in the scope of the embrittlement surveillance program of major primary components
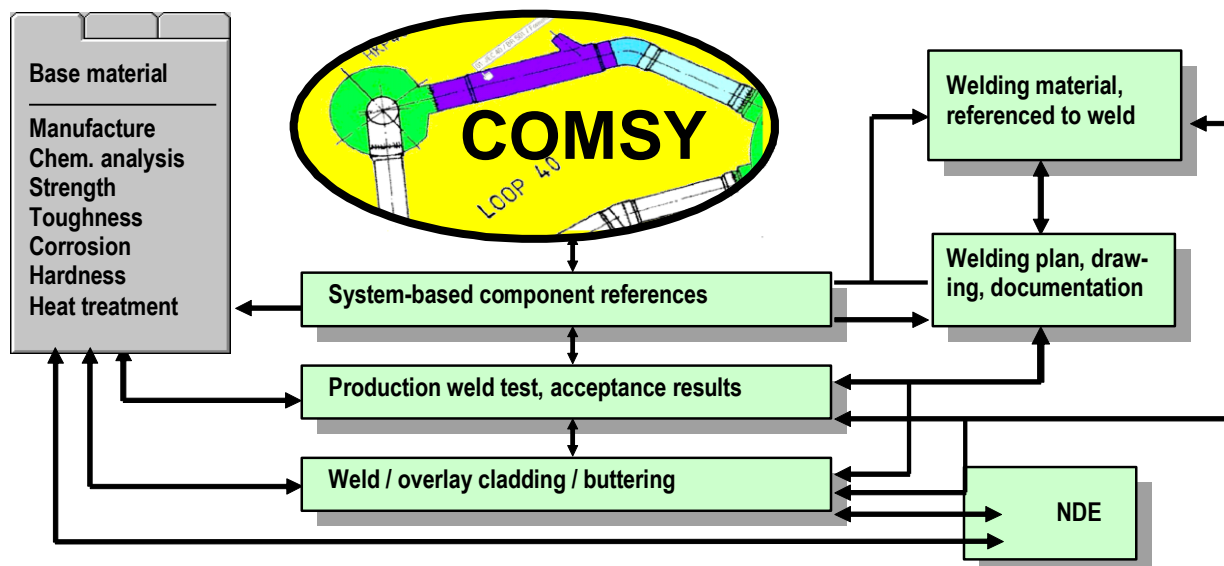
If a corresponding record exists, COMSY uses the "as-built" material properties of the component instead of standard material library properties for assessing degradation mechanisms. In this process, complex data associations allow the retrieval of material properties as well as the identification of other components made from the same heat.

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Module M9: Active components reliability

Features:

- Provides reliability performance indicators for a wide range of power plant components
- Components models based on sub-components and consumables
- Reliability performance indicators are updated via the operational experience feedback program

Description:

Maintenance needs for active components (e.g. valves, pumps, etc.) can be assessed based on industry experience regarding symptoms and root causes of system malfunctions. The Active Components module provides the technological basis for predictive/prognostics capabilities by providing a range of typical reliability performance indicators for key power plant components.

The functionality is based on an equipment library for a wide range of power plant components including reliability performance indicators. This library has the capability to resemble sub-components and consumables with their respective life limitations which may impose on the main component.

The functionality is interconnected with the Operational experience feedback program, which systematically records failures experienced with certain components by utilizing failure mode classifications (FMEA - see module G4). This provides the information basis for updating and validating performance indicators for power plant components stored in the equipment library.
The evaluation of maintenance and inspection feedback utilizes statistical feedback information to optimize the effort according to economic criteria considering availability and safety requirements. This includes probabilistic approaches to determine updated MTBF (mean time between failures) values for the components considered using the Weibull approach.

Risk Based Asset Management, Prioritize and optimize maintenance program

RBI

Evaluate experience Failure Rate, MTBF, Weibull

RCM

COMSY single source SQL Database

AP913

FMEA

Check industry experience and failure/event reporting, FMEA classification

FMEA
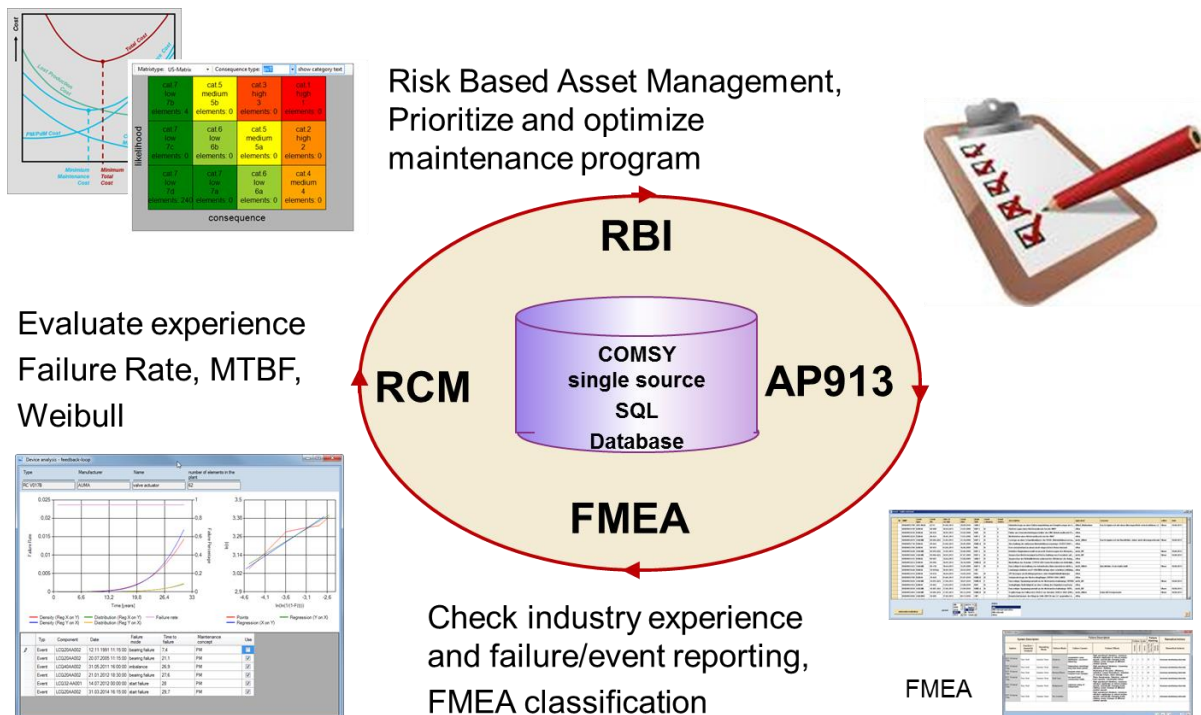
Failure rates for safety relevant equipment need to be monitored within the frame of aging management. If done systematically, the results can be utilized to periodically optimize the maintenance programs. This activity is intended to be part of the Equipment Reliability Process according to AP-913.

Module M10: Rule based degradation assessment for license renewal application and lifetime extension

Features:

- Supported Codes:
  - Lifetime extension based on IAEA guideline
  - License renewal and subsequent license renewal based on US NRC Guideline
- Assessment of potential degradation mechanisms by applying guideline specific exclusion rules
- Report generation in line with respective guideline

Description:
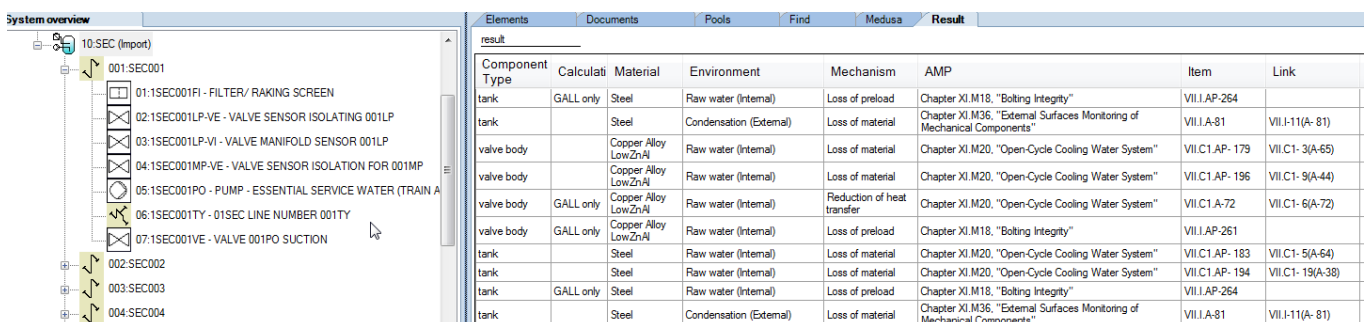
The knowledge about the degradation potential of a system, structure or component (SSC) is a key aspect in the Aging Management process and long term operation of nuclear power plants. Only by identifying them, the existing counter measures can be proven and enhanced if necessary.

The second aspect is the large amount of data needed for a reliable degradation analysis, e.g. operation parameters, material properties, water chemistry or geometrical information. Using the typical amount of safety related components in scope of an aging database, which is around 30.000 to 40.000 SSCs per plant unit, data collection and data keeping is the major task for such an application.

COMSY is supporting this task by sophisticated and flexible import functions, document and quality management and included libraries for materials, steam table functions, water chemistry calculation etc., as described in the "General functions for data handling" (modules G).

To further optimize the license renewal process, which is typically the start for building up an Aging knowledge base; the module M10 uses simplified prediction models resulting in Yes/No statements using specific exclusion rules. Depending on the customer's application this rules are coming from EPRI tools, Framatome CAM rules or plant specific exclusion rules.

Advantage of this approach is that only the minimum required set of data needs to be collected for a system. For example, in many cases temperature or fluid type are sufficient to include/exclude specific degradation effects, whereas detailed material properties, operation mode, mass flow, pH value, oxygen content etc. can be neglected in a first step. This simplifies collection of aging parameters and accelerates authority approval by using such exclusion rules.

Example for a simplified degradation assessment for a service water system with GALL and EPRI Tools

In combination with module G2 similar groups of components can be formed automatically and results from IGALL or GALL experience are added automatically. Together with module G3 where all used documents can be included for each SSC the knowledge base is ready to use in a very short time. The usage of COMSY accelerates this process by more than 50% compared to standard license renewal applications where all this information needs to be documented manually. A further advantage of an electronic data source is that data can be continuously updated using integrated update functions which avoids the effect of collecting only a frozen plant status valid for the time of the creation. New degradation knowledge or updated experience can be implemented efficiently and the data can be used for subsequent reporting applications with a minimum of modifications.

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COMSY-ELT – The Module for Aging and Plant Life Management of electrical equipment and I&C

The objectives of aging management of electrical systems and equipment in harsh environment areas serve primarily to ensure a sufficient degree of reliability of the safety systems necessary to mitigate design basis events, and to avoid any significant increase of aging related common mode failure potential. Similar objectives are followed for the operational part of the plant in order to avoid a loss of availability. The key objectives of the aging management are: a) maintaining the relevant systems and equipment to function on demand within boundary conditions to be met, and b) predicting future life time depending on the actual service conditions and the environment at the respective location.

This applies for all relevant parts of the so called function chains consisting generally of e.g. cable penetrations, junction boxes containing terminal blocks, power cables, signal cables, drives, solenoids, sensors and transducers distributed within the containment or similar places

The handling of electrical equipment and I&C in harsh and mild environment is accomplished by the integrated software module which is part of COMSY software platform for Aging and Plant Life Management, ensuring effective data handling in a single-source database, also providing synergies between aging management applications on different fields of engineering.

The ELT (ELectroTechnology)-Module provides support to address the following generic features:

- Management of cable materials and the history of environmental conditions
- Verification of function chains, specification of respective function chain members
- Determination of all relevant parameters required for lifetime analysis
- Life time analysis and qualification
- Demonstration (by analysis) if and how respective requirements are fulfilled
- Management and trending of inspections on components, cables or function chains to calibrate and validate the prediction result
- Support for the replacement of function chain members or designing new function chains
- Comprehensive reporting tools

Framatome provides the following functional modules of the ELT-Module:

- Module E1: Lifetime analysis of equipment in harsh environment
- Module E2: Aging and plant life management in mild environment
- Module E3: Function chains modeling, managing and evaluation
- Module E4: Risk informed prioritization of inspection activities
- Module E5: Examination data management

The functionality of the COMSY-ELT-Module provides an efficient process for tracing of plant condition due to aging effects, their causes and helps to implement counter measures.

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Module E: User interface and basic platform for plant modeling (see also G1)

Features:

- User friendly Windows® based user interface
- Function chains mapping and managing
- Engineering tools and equipment catalogs
- Element addressing, visualization and editing of data structures
- Network compatible database interface (Microsoft SQL server)
- Managing, printing and exporting data applying MS-Office compatible formats

Description:

The software product COMSY-ELT is operated under Windows and uses the same database as applied for the mechanical components and civil structures. The user interface and basic platform supports the handling of relevant electrical systems and equipment in the harsh and mild environment situations. It provides the functionality to model electrical systems as functional chains. Furthermore, each function chain is subdivided into individual chain member with respective data sheets.
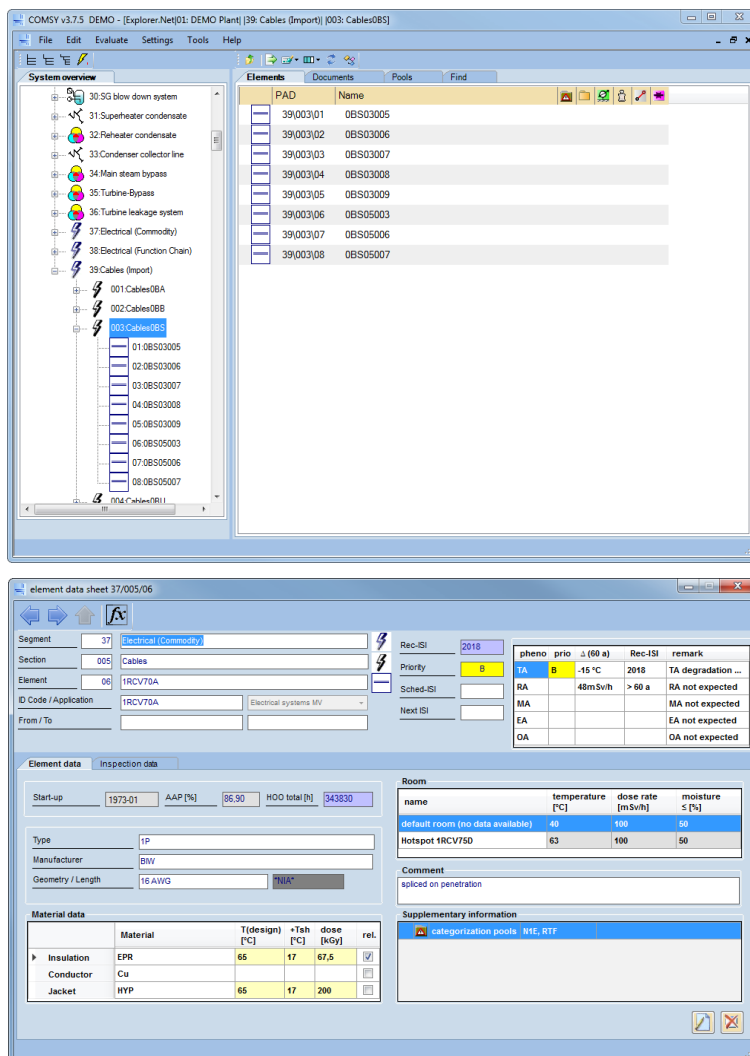
This specific approach provides on the one hand the basis for evaluating potential degradation and on the other hand the basis for editing the chain member data, e.g. date of start of service, changes in the environment or the replacement of the chain member.

Potential replacements are supported by a corresponding link to the equipment library, where qualified spare parts may be found.

The modeling process is supported by:

- An equipment catalog
- Tools for specifying environmental loads in associated room pools and hotspots
- Service history records
- Equipment Data Sheets

All data can be imported automatically and edited manually, but because of the high amount of data an automatic import is recommended.

Data import is possible from Text or Excel-Exports, Access databases and other data sources. Depending on the data the import function may have to be adapted to the customer needs.

The graphical user interface allows for efficient data keeping and/or building up a plant model for electrical equipment. It serves to manage component related and environmental conditions. An integrated pool data manager supports the organization of relevant data regarding the grouping of variable parameters, types and commodities and the specification of related compartments and hot spots. In addition, it assists by generating cable runs and function chains.

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Module E1: Lifetime analysis of equipment in harsh environment

The data management functionality supports the following tasks:
- recording of plant specific data, as environment and relevant equipment data
- updates on demand in terms of changes of values of local loads or equipment replacements
- recording of the equivalent full load days at the end of each fuel cycle
- triggering a new calculation of e. g. current losses or remaining qualified life time based on updates introduced
- starting a corresponding print out

Determination of qualified life of experimentally qualified equipment

The calculation of remaining qualified life is generally performed, comparing the qualification parameter value pares like qualification temperature and time, and dose rate and time with the corresponding measured accumulated environmental loads at the location of the piece of equipment since it was installed, considering the adequate thermal activation energies and the respective exponents for radiation aging.

Determination of qualified life of polymeric materials / equipment stored in high load areas
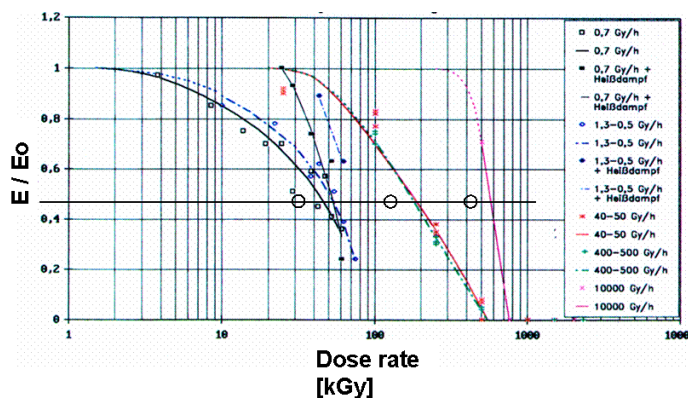
The determination of qualified life of polymeric materials / equipment stored in high load areas, e.g. cable samples, is generally done similarly to the determination of experimentally qualified equipment. But in addition parameters like elongation at break could cyclically be measured in order to achieve trend information, which in turn allows for life time prediction which may exceed the formal qualified life

Equipment catalog

The equipment catalog function provides the potential to record all relevant design and qualification data of equipment types installed, dedicated to categories of function chain types, and function chain members constituting these chains. Once the corresponding data for a specific plant have been acquired and recorded, they can be used to design additional function chains. If necessary, the data can be updated by the user. The data in the catalog include in addition the properties of the materials determining the sensitivity against thermal and radiation loads.

Environmental loads and service history

Once, the environmental loads have been determined (in general, increased temperature, irradiation, and may be moisture, mechanical vibration, mechanical loads and / or chemical substances) they are recorded linked to the respective function chain member. That is, as far as reasonable, these values are no integral ones rather than equipment specific, in order to take the maximum advantage of the load variation versus distance.

Service loads – if there are any, because the majority of the electrical safety grade equipment is not operated during normal plant operation and sensors and transducers produce generally no heat losses, and are correspondingly not self-heated – are primarily addressed by design and general qualification.

Module E2: Aging and plant life management in mild environment

The objectives of the aging management of electrical and I&C systems and equipment in mild environment serve primarily to ensure a sufficient degree of availability of the safety systems necessary to mitigate all relevant design basis events, and to avoid any significant increase of aging related common mode failure potential. These objectives are in accordance with the general requirements of the German standards KTA 1403 and KTA 3706, the US standard IEEE 323, and the international standards IEC 60780 and IEC 62342.

A reasonable aging management of electrical and I&C equipment in mild environment areas is primarily based on the systematic application of established procedures to avoid or detect potential unacceptable aging related degradation, and/or mitigate potential unacceptable aging related consequences: Accordingly the systematic application of experience based measures and procedures constitutes a solid basis to detect implicitly and broadly potential unacceptable aging affecting the function of electrical and I&C equipment in time; the key issue of aging management. In addition, aging can be predicted by comparisons based on a broad statistical collective of comparable systems in operation; the effects and the consequences of the potential loss of function can be evaluated. Measures to cope with potential functional losses can be defined if necessary.

Measures and Means for Aging Management

The aging management of equipment in mild environment areas and harsh environment areas is to the major extent similar, regarding the general aging management objectives.

These vital objectives will be met to the major extent possible by the following measures:

- Reasonable achievable prevention of aging related failures (if they appear, they appear statistically distributed versus time and system) by preventive maintenance to preserve functionality

- Systematic / periodic testing to check if functional capability is still given

- Systematic feedback / consideration of experience gained during operation and repair.

The figure on the left side illustrates the defense in depth methodology applied. If indicated, time periods for a possible systematic replacement has to be chosen depending on the kind and the potential impact of the operational load, on recommendations of the supplier, on the results of trending analysis based on periodic testing and calibrations, detected simply during normal operation, or on proven fixed time periods. Within the scope of aging management related collective of measures, periodic testing, preventive maintenance, and self checks contribute significantly to achieve the availability objectives. A list of dedicated periodic testing measures and preventive maintenance measures needs to be prepared addressing type and amount of periodic tests and typical preventive maintenance measures of the most important parts of the electrical systems. Their specific contribution to achieve the safety objectives have to be qualitatively evaluated

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Module E3: Function chains modeling, managing and evaluation

COMSY-ELT is a computer based tool which allows for periodically checking whether every single piece of I&C and electrical equipment operated in harsh environment is still in the position to fulfill the required function necessary to mitigate design basis events. This check consists of the following functions:


- Comparing qualification parameter values with actual environmental parameter values in order to check, if a relevant piece of equipment is qualified at all for a given function and location (helpful specifically in cases of necessary replacement)

- Comparing qualification parameter values with actual environmental parameter values in order to determine the remaining "qualified life"

- Check, whether the total sum of the leakage current of all members of an electrical function chain – simultaneously affected by LOCA consequences – does not trigger a trip of the dedicated protective device

- Check, whether the kind and sum of measured value deviations of an I&C function chain – simultaneously affected by LOCA consequences – do not impair the parameter value to be measured inacceptable (depending on the respective signal conditioning device)

- Storing and printout of the calculated results clearly arranged, in the sequence the of members of the function chain starting with the respective sensor or actuator including all necessary information to judge if the results are reasonable (important specifically for third persons)

- The intervals and corresponding updates of calculations will be adapted to refueling phases, in cases the data which have to be acquired have to be collected from equipment mounted in areas not accessible during normal operation.

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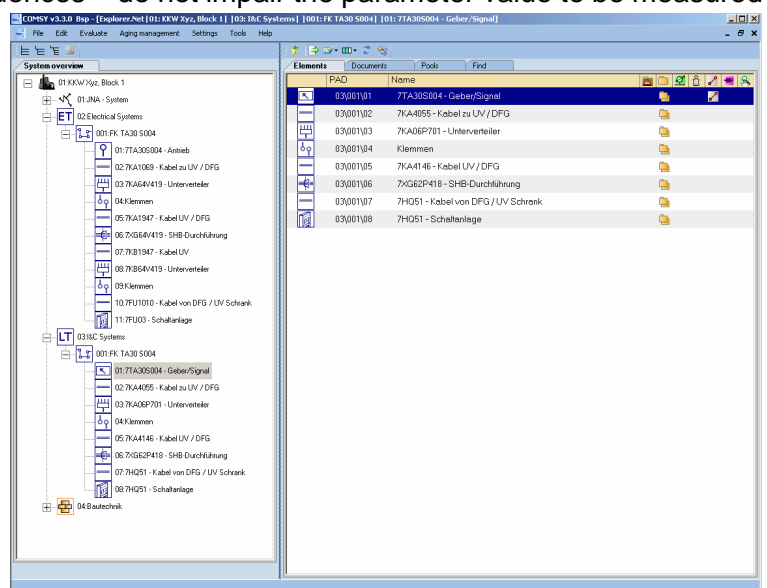
Module E4: Risk informed prioritization of inspection activities

The process of the risk-informed inspection planning integrates service experience, the knowledge of plant design aspects, information on relevant degradation mechanisms and risk insights. The main objective is to generate a dependable ranking of components or locations to be inspected based on the insights from the consequence assessment and degradation potential evaluations.

For this purpose, the function manages risk-related parameters and assesses the likelihood of qualified thermal and radiologic life time based on Deterministic-Based methods. For this activity COMSY provides a comprehensive user interface, which efficiently supports the risk-informed assessment process.
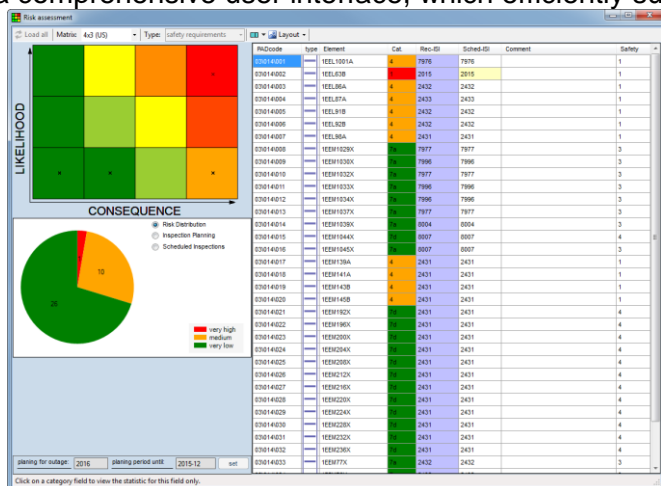
The integrated risk-matrix and respective ranking functions serve to focus inspection activities on safety related equipment with an existing degradation potential. The computer guided ISI selection procedure supports the user friendly generation of an ISI schedule. In addition, it allows for engineering judgment interactions.

The COMSY software provides integrated RI assessment functions with quantitative failure risk assessment based on lifetime prognosis, which makes the RI-ISI process highly effective. Major savings can be achieved especially for the RI-ISI follow-up programs, as the RI-ISI programs must be regularly updated.
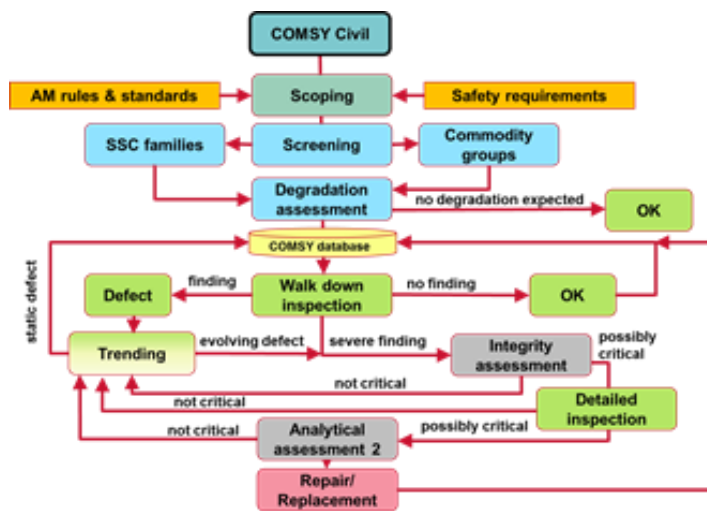
Module E5: Examination data management

This module handles the storage, administration, evaluation and documentation of examination results. Examination data are utilized for further lifetime predictions with increased prediction accuracy.
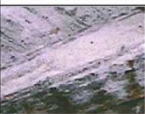
COMSY is able to flexibly store and evaluate any kind of electrical measurement (e.g. Partial discharge, Tan Delta, Reflectometry etc.) as well as visual examinations or specific tests. All measurement values can be trended over time or compared with each other. This helps to identify changes over time or deviations between similar groups. User defined thresholds can be used to give warnings in case of threshold violations to allow for planning of early preventive actions

This process ensures that experience gained from evaluation of examination data will be fed back into the performance of analytical service life predictions. Examination data resulting from in-service inspections are thus consistently used in the preparation of a reliable database which is kept continually up to date. The quality of the condition documentation will continue to increase with every year the process is in use

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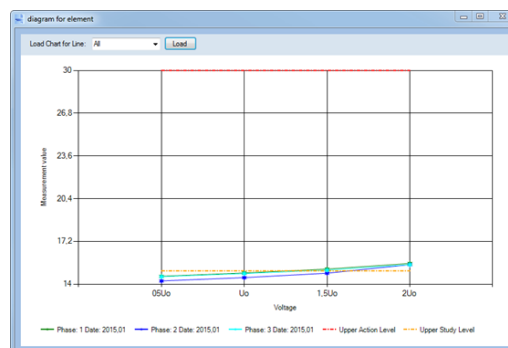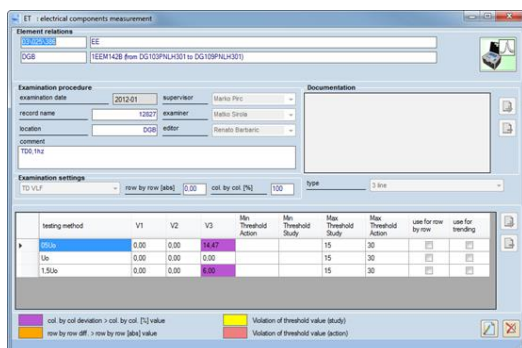
COMSY-Civil – The module for Aging and Plant Life Management of civil structures

Structural components are plant specific and cannot be replaced in most cases. Structures may be subject to time-dependent changes that may impact their ability to withstand various degradation modes.

The degradation mechanisms for civil structures can be categorized in three different categories which are loss of material (e.g. abrasion, freeze-thaw, corrosion, etc.), cracking (e.g. settlement, fatigue, irradiation, shrinkage, etc.) and change in material properties (creep, aggressive chemicals, etc.). The evaluation of the relevant degradation mechanism for civil structures is based on the stress factors like e.g. elevated temperatures, low temperatures, irradiation and aggressive environment.

Functionality of COMSY CIVIL provides a living aging management program featuring:

- General aging management features
- Scoping & screening
- Degradation assessment
- Prioritization of activities
- Concrete crack inspection
- Trending of defects
- Integrity assessment
- Reporting

The functionality relates to the action plan according to ACI (American Concrete Institute)

Knowledge and understanding of degradation is essential for an efficient condition monitoring of structures and is vital for the aging management process. The COMSY software supports the civil engineer in predicting degradation modes based on environmental conditions e.g. operating temperatures, chemical stressors and material properties. In case of sensitive structures, the degradation progress can be periodically evaluated by applying a closed loop surveillance process considering changes in operating environment and material properties.

The COMSY Civil-Module provides the following features:

- Management of civils SSC considering material, design, history of environmental conditions
- Degradation assessment, RI-based prioritization based on criticality
- Lifetime assessment based on concrete carbonation and chloride diffusion calculations
- Inspection management and inspection feedback evaluation
- Trending of defects and remaining life analysis
- Analytical integrity assessment and in-depth assessment, if indicated
- Periodic reporting of as-is condition of civil structures and outlook.

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Module C: User interface and basic platform for plant modeling (see also G1):

Features:

- User friendly Windows® based user interface
- Engineering tools and component catalog
- Element addressing, visualization and editing of data structures
- Network compatible database interface (Microsoft SQL server)
- Managing, printing and exporting data applying MS-Office compatible formats

Description:

The software product COMSY-Civil is operated under Windows and uses the same database as applied for the mechanical components and electrical module. The user interface and basic platform supports the handling of relevant civil structures and buildings.
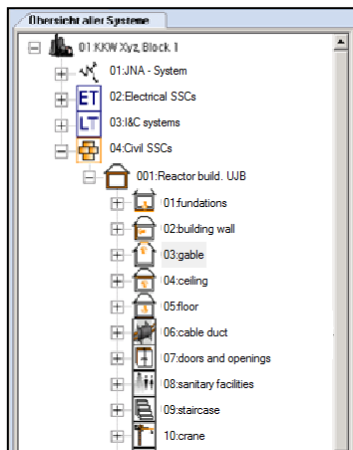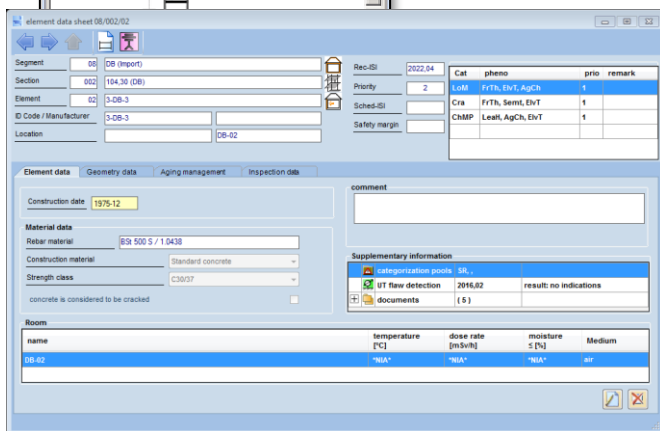

The modeling process is supported by:

- A function for specifying environmental loads in associated room pools and hotspots

- Service history records

- Equipment data sheets

All data can be imported automatically and edited manually, but because of the high amount of data an automatic import is recommended.

Data import is possible from Text or Excel-Exports, Access databases and other data sources. Depending on the data the import function may have to be adapted to the customer needs.


The graphical user interface allows for efficient data keeping and/or building up a plant model for electrical equipment. It serves to manage component related and environmental conditions. An integrated pool data manager supports the organization of relevant data regarding the grouping of variable parameters, types and commodities and the specification of related compartments and hot spots.

Furthermore, the software supports plant walk downs with a Framatome developed tablet solution that helps to plan walk downs, assess the plant condition by plant specific assessment protocols and automatic import of the results.

Framatome provides the following functional modules of the Civil-Module:

- Module C1:   Degradation Sensitivity Assessment Functions
- Module C2:   Risk informed prioritization of inspection and maintenance activities
- Module C3:   Examination data management

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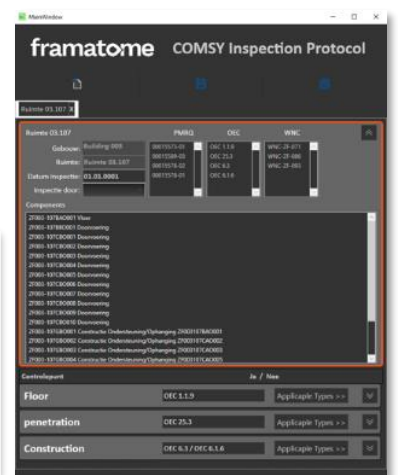
Module C1: Degradation Sensitivity Assessment Functions

Degradation assessment for the following aging effects and mechanism:

- Loss of material (Freeze-thaw, Erosion, Abrasion, Cavitation, …))
- Cracking (Shrinkage, Settlement, Elevated Temperature, …
- Change in material properties (Leaching, Aggressive Chemicals, Irradiation, …

Description:

The process of Aging Management has the objective to monitor and control degradation effects which may compromise the integrity of components. Target is the identification of possible degradation mechanisms and to ensure that adequate inspection programs are applied.

The degradation assessment process requires the knowledge of component design aspects, material data, operating conditions and chemical data. The main objective is to generate a dependable ranking of components or locations to be inspected based on the degradation potential evaluations.

Ageing Effect / Mechanism	Air - Indoor	Air - Outdoor	Air – With Borated Water Leakage	Embedded in Concrete	Raw Water – Stagnant	Raw Water – Flowing	Soil	Soil/Groundwater
Loss of material								
Freeze-thaw		X			X	X		X
Erosion, Abrasion or Cavitation						X		
Elevated Temperature	X	X	X		X	X		
Aggressive Chemicals	X	X	X		X	X		X
Corrosion of Embedded Steel and Steel Reinforcement	X	X	X	X	X	X		X
Cracking								
Freeze-thaw		X			X	X		X
Reaction with Aggregates		X			X	X		X
Shrinkage	X	X						
Settlement		X			X	X		X
Elevated Temperature	X	X	X			X	X	
Irradiation	X	X	X		X	X		X
Fatigue	X	X	X		X	X		X
Change in Material Properties								
Leaching of Calcium Hydroxide	X	X	X		X	X		X
Aggressive Chemicals	X	X	X		X	X		
Elevated Temperature	X	X	X		X	X		
Irradiation of Concrete	X	X	X		X	X		
Irradiation of the Reinforcing Steel	X		X					X
Creep	X	X	X		X	X		

For this purpose, the function assesses the likelihood of the occurrence of degradation mechanisms based on the given component/structure data in each case including type, material and environmental conditions. Furthermore, the inspection experience is considered, if available. Based on the above results, components are categorized in respect to degradation sensitivity groups.

The real condition of the structure can be proven by pictures taken during the plant walk downs, which is supported by a Tablet Application, see also other civil modules. This closes the degradation assessment feedback loop.

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Module C2: Risk informed prioritization of inspection and maintenance activities

Risk informed prioritization of inspection activities is based on degradation assessment results generated by Module C1. The function includes
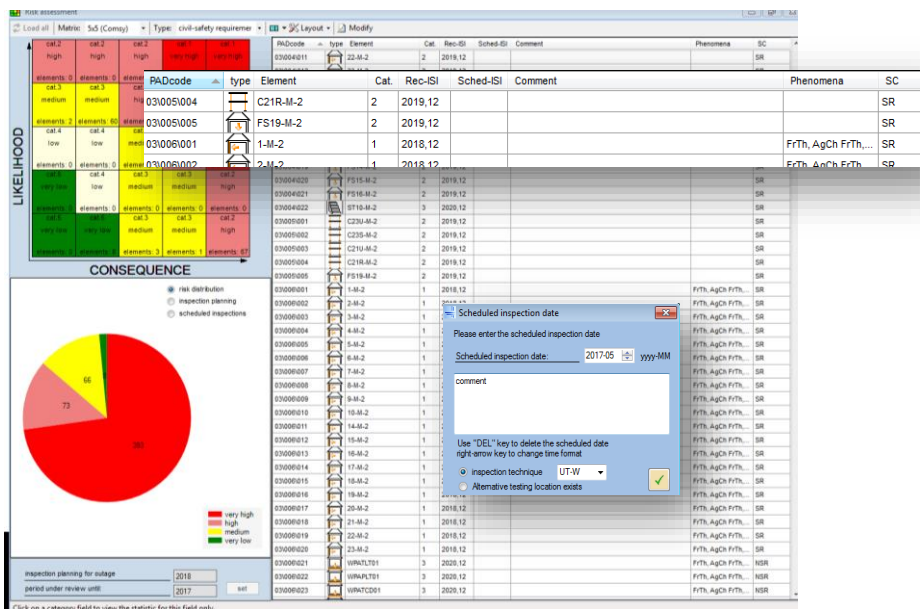
- Functions to manage risk-related parameters
- RI-Methodology related functions and visualization
- User interface for selecting and managing inspections

Description:

The process of the risk-informed inspection planning integrates service experience, the knowledge of plant design aspects, information on relevant degradation mechanisms and risk insights. The main objective is to generate a dependable ranking of components or locations to be inspected based on the insights from the consequence assessment and degradation potential evaluations.

For this purpose, the function manages risk-related parameters and assesses the likelihood of the occurrence of degradation mechanisms based on the given degradation models (Module C1).

The procedure for defining the measure for failure consequence in COMSY is based on the type of civil component or structure. Also existing safety classes, inspection groups can be used as a measure.


User Interface for RI-ISI Applications

For this activity COMSY provides a comprehensive user interface which efficiently supports the risk-informed assessment process.

The integrated ranking function serves to focus inspection activities on safety relevant elements with an existing degradation potential. The computer guided ISI selection procedure supports the generation of an ISI schedule and the selection of appropriate inspection techniques for the respective item. In addition, it allows for engineering judgment interactions.

The COMSY software provides integrated RI assessment functions with quantitative failure risk assessment based on degradation prognosis, which makes the RI-ISI process highly effective. Major savings can be achieved especially for the RI-ISI follow-up programs, as the RI-ISI programs must be regularly updated.

Based on the evaluation, the next inspections can be planned. When using the Framatome Tablet Inspection App, the resulting inspection tasks can be automatically exported in a digital protocol for the device. If the rooms (environmental conditions) are existing in the database, the protocols can be prepared by room, which greatly simplifies the inspection walk down.

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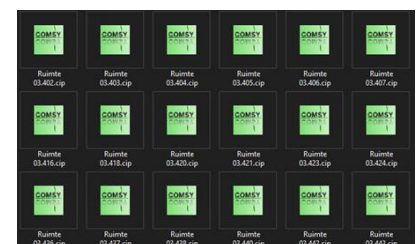
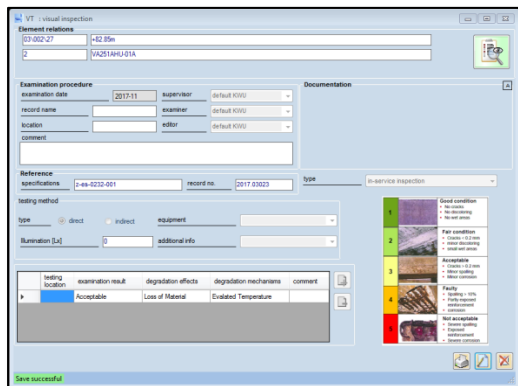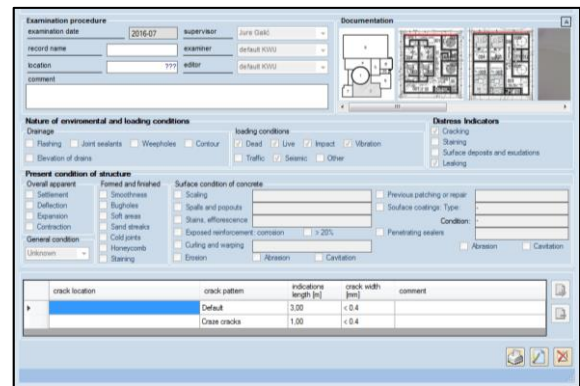## Module C3: Examination data management

Features:
- Data input forms for Civil visual inspection examination records
- Examination data input from ACI* inspection protocols including drawings and pictures
- Plan, conduct and assess results of plant walk downs with the Tablet inspection protocol
- Inspection summary report

*ACI = American Concrete Institute

This module handles the storage, administration, evaluation and documentation of NDT examination results. Examination data are utilized for further lifetime predictions with increased prediction accuracy. The examination and inspection results are linked to the examined component for documentation of the as-is condition at that specific time in the operating history of the plant, and are integrated into the virtual power plant data model.
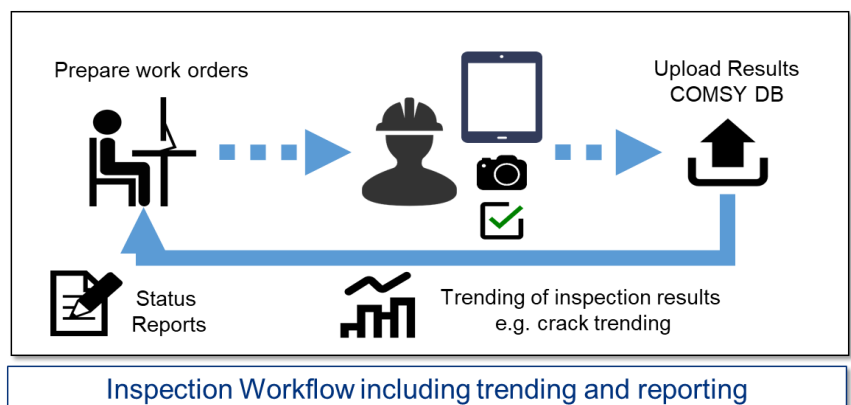
The evaluation of component examinations is supported by e.g. interactive analysis and reporting functions. Examination data resulting from in-service inspections and plant walk downs are thus consistently used in the preparation of a reliable database which is kept continually up to date.
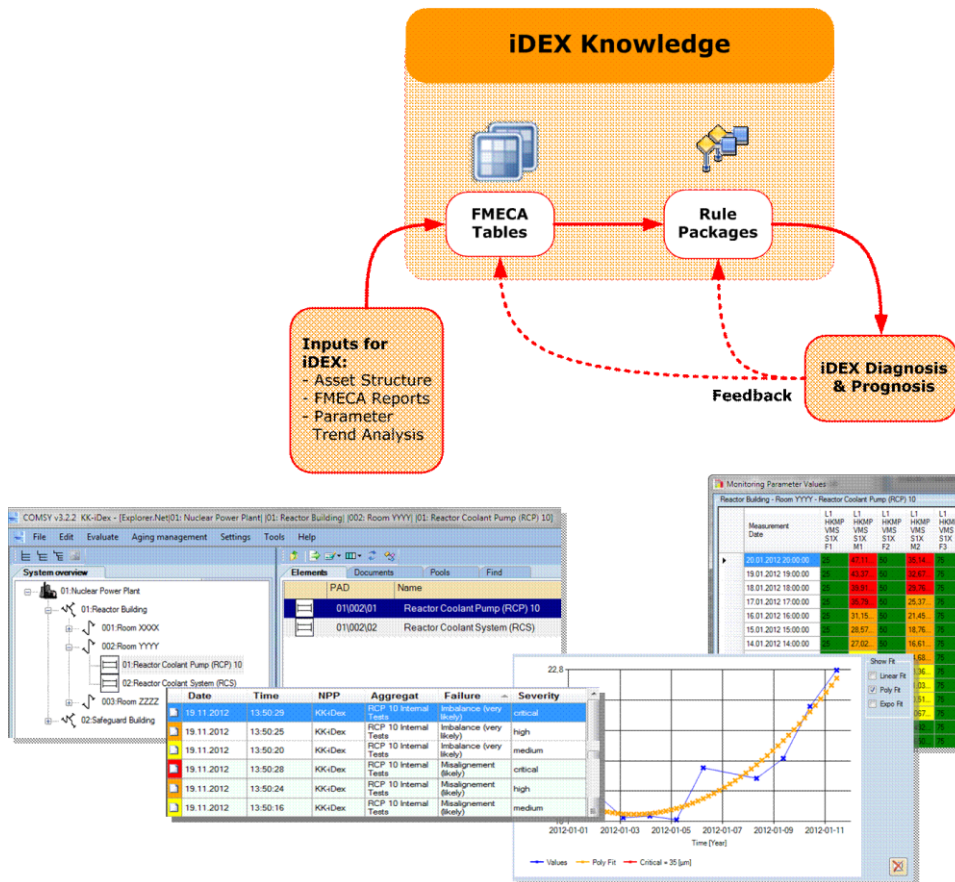

This process increases the informational value of the examination results, and makes it possible to provide a legible description of the as-is condition of civil components and buildings. The quality of the condition documentation will continue to increase with every year the process is in use.

Due to the huge amount of inspections an import functionality for inspection protocols is available. All data of the ACI Excel sheets or from the Framatome Tablet inspection protocol will be collected including pictures of the real condition. With this functionality all civil inspections and photos of a year can be imported automatically in a few minutes. Predefined protocols help to assure a consistent and standardized assessment. Pictures can be directly taken in the Tablet Application and key results like crack dimensions are safely stored in the related field, which avoids mistakes and wrong interpretation.

The Inspection summary report gives an overview of the civil inspections of a selected time period (e.g. one year) and sums up basic information like the number of inspections. Also findings grouped by type and sum of length of all cracks are given in the report. With this report the current status of the civil structures can be shown and compared to the last years to show a trend.

Inspection Workflow including trending and reporting

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iDEX – The integrated Diagnosis & Prognosis Module of COMSY for Aging Surveillance of equipment

iDEX connects COMSY with online data from Diagnostic & Monitoring systems

- Automatic data import from connected systems
- Plant structure mapping
- Trend analysis (incl. regression analysis)
- Data analysis according to equipment operating condition (clustering)
- Diagnosis on basis of logical rule packages
- Automatic diagnosis & prognosis proposal with indication of event severity (color indication)
- Event standard reports

- Maintenance support and asset management

- Easy and harmonized access to monitoring systems

- Concentration of monitoring & diagnosis and plant data of several systems in one integrated platform (COMSY knowledge database)

- Automation of diagnosis & prognosis tasks: Measurement data is conveyed automatically to maintenance recommendations (fault identification, not only fault detection)

- Full integration with aging management functionality of the Framatome COMSY software

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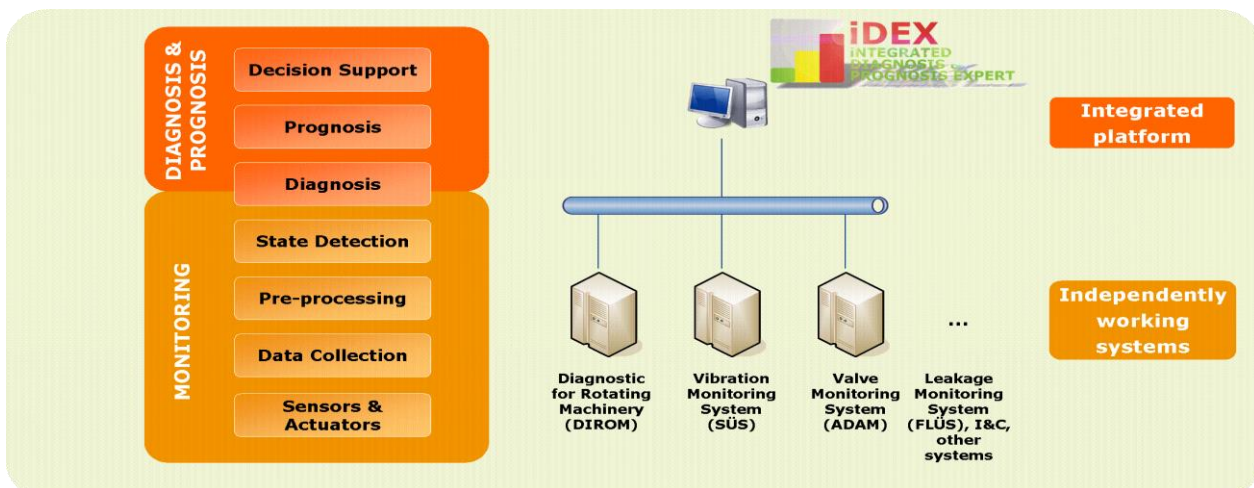
COMSY-DIWA – Software for Tracking and Analyzing of Water Chemistry Conditions

The operation of a power plant requires optimum water chemistry and a high degree of system corrosion protection. The purpose of a computer-supported, extensively automated diagnostics system is reliable and rapid detection and localization of incipient disturbances or disturbances which have already occurred in the water-chemistry conditions of the water/steam cycle.

DIWA is a software tool which allows users to track and to analyze the water chemistry conditions. For this purpose, DIWA reads relevant chemical and thermodynamic data from the plants I&C system, displays, checks and analyses the data and carries out diagnosis to identify and report possible disturbances.
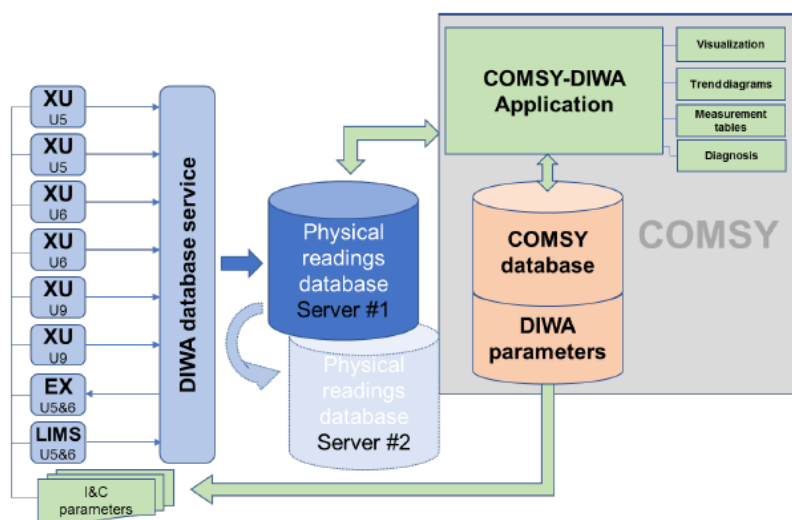
The DIWA diagnostics system is based on the on-line acquisition and monitoring of chemical and thermodynamic measurement values. The data made available by the process I&C have to be constantly acquired and checked for plausibility. The user interface can be used at any time to analyze the stored data based on a wide range of criteria. Data storage provides the interface between the background system and the user interface.

The key features of the DIWA diagnostics system are the following:

- On-line acquisition of relevant chemical and thermodynamic parameters

- Off-line acquisition of laboratory data

- Consideration of plausibility

- Calculation of parameters from acquired data

- Long-term data storage of the most important data and parameters for later analyses

- Comparison of current values with set points

- Display of measurement values and parameters in process displays

- Free-form graphical display of measurement values and parameters in diagrams

- Time extrapolation of curves for trend plots

- Information regarding operating condition of the water/steam cycle

- Immediate reporting of detected disturbances

- Processing of diagnoses (description, explanation, corrective measures, recommendations, evaluation)

- Printout of logs and hard copies of screen contents

Automated email service indicating alarm violations and diagnostic results.

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