SIEMENS energy

Life Time Assessment Life Time Extension

A profitable way to continue operation for decades

General information

The driving forces behind Siemens Energy Power Generation Services is our dedication to speed of response and always being close to the customer. This is because one of our major goals is to deliver sophisticated services fast – services that are designed to increase the life cycle of your plant's assets, improve efficiency, and fit perfectly with your plant's performance needs and your business targets.

Our global network plays a central role in helping us meet this commitment. With locations strategically positioned across the globe, our close proximity to customers ensures that Siemens Energy vast resources and strong expertise are readily available to provide customized and dependable solutions. We are present in 178 countries worldwide and our 17 product competence centers and 25 service shops offer world-class logistics to deliver fast and effective results.

Introduction

Aging steam turbines require your attention

An increasing number of industrial steam turbines are operated beyond their design lifetime. **Operating a turbine for extended periods beyond the end of its normal design lifetime may result in increasing failure risk and unplanned outages.**
Each turbine is unique! Most of them are designed for over 100,000 operating hours but their real life time depends on

- Operation profile of the turbine
- Performed scope and intervals of maintenance
- Possible calculation margins.

Our global network plays a central role in helping us meet this commitment. With locations strategically positioned across the globe, our close proximity to customers ensures that Siemens Energy vast resources and strong expertise are readily available to provide customized and dependable solutions. We are present in 178 countries worldwide and our 17 product competence centers and 25 service shops offer world-class logistics to deliver fast and effective results.

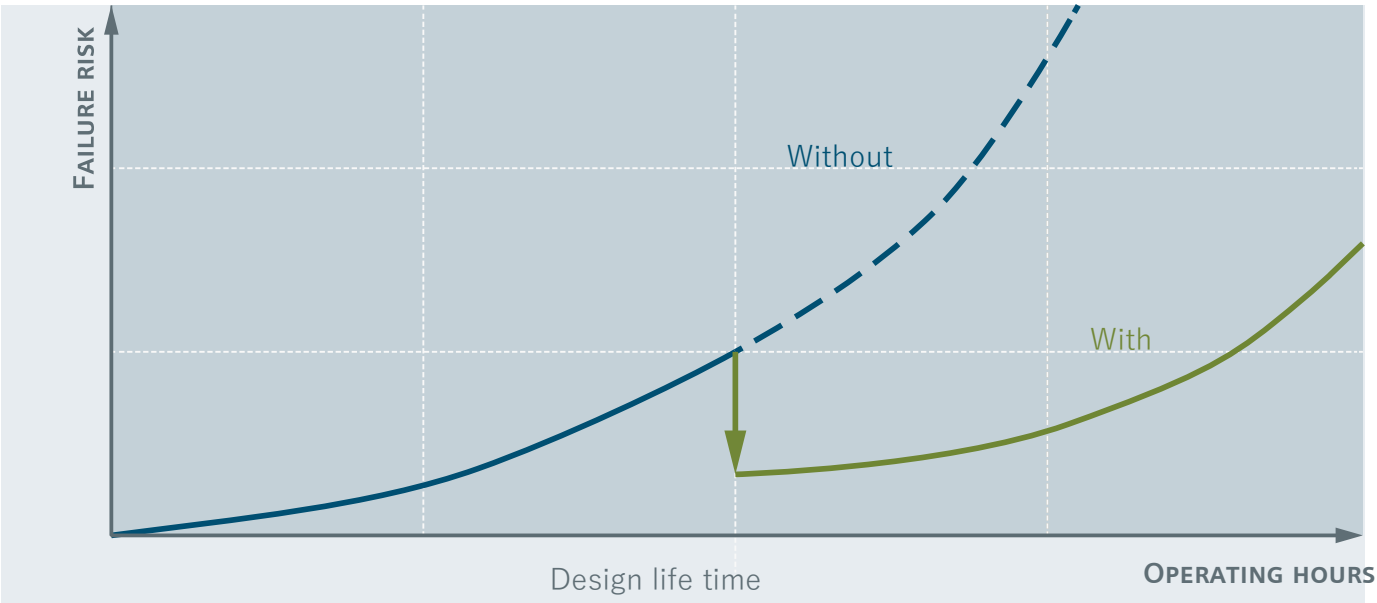


Figure 1: Failure risk during turbine lifetime

Continuing profitable operation for decades

Reliable turbine operation is often of great importance. The high investment cost and long delivery time of new equipment make it worth considering the alternative of LTE. The comprehensive LTA/LTE program available from Siemens Energy can help to secure future reliable operation of a turbine approaching the end of its design lifetime. It is recommended to perform Siemens Energy LTA/LTE program latest at 100 000 equivalent operating hours (EOH).

After careful investigation by our experienced engineers, it could be possible to extend the operating life of the turbine plant by tens of years at a limited investment cost. In some cases the cost could be restricted to the inspection cost only. In other cases, additional benefits can be gained in performance or efficiency when replacing old parts with modern equipment. This depends on the assessment of our engineers in each individual case.

Mechanisms that limit component life

The real lifetime of turbine components depends on the individual operating conditions and maintenance. The three dominating factors of expected component lifetime in high-temperature turbine plants are material creep, low cycle fatigue and thermal aging. High temperatures combined with high stress levels accelerate damage to components such as steam piping, inlet valves, high pressure (HP) turbine casings and rotors. At the exhaust end, corrosion and erosion, combined with high stress, reduce the lifetime of low pressure (LP) turbine parts and heat exchangers. Similarly, electric generators are affected by thermal, electrical, mechanical and environmental factors, which can lead to lower output and efficiency as well as

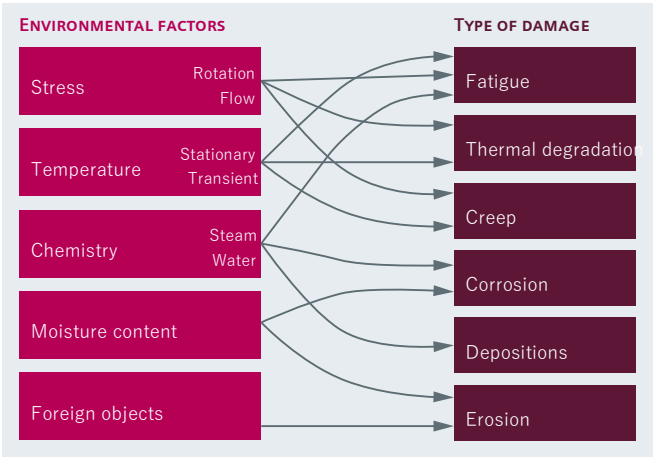


Figure 6: Failure mechanisms



Figure 2: Stress corrosion cracking in a rotor operated with impure steam with



Figure 3: Broken inlet steam pipe due to fatigue in a position exposed to high

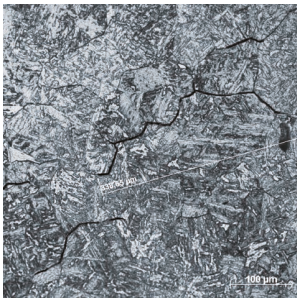


Figure 4: Creep damages in class 4b which mean micro cracks length between 400 µm and 2 mm



Figure 5: Severe deposition due to impure steam which mean a rough surface finish and also a reduced steam channel

LTA/LTE program

Siemens Energy has developed a program for the Life Time Assessment (LTA) and Life Time Extension (LTE) of industrial steam turbines.

The program consists of three main parts: LTA Desktop study, LTA and LTE

General information

Siemens Energy has accumulated experience from thousands of turbines operating all over the world. Material tests have, for many decades, been conducted in our own laboratories. Our engineers have wide ranging experience on the various techniques available for identifying critical components and assessing their remaining lifetime. The foundation is original design calculations updated with today's design criteria and when needed, complemented with high technological FE-based calculation. The combination of this experience and the bank of information available within Siemens Energy form the basis of the LTA/LTE program.

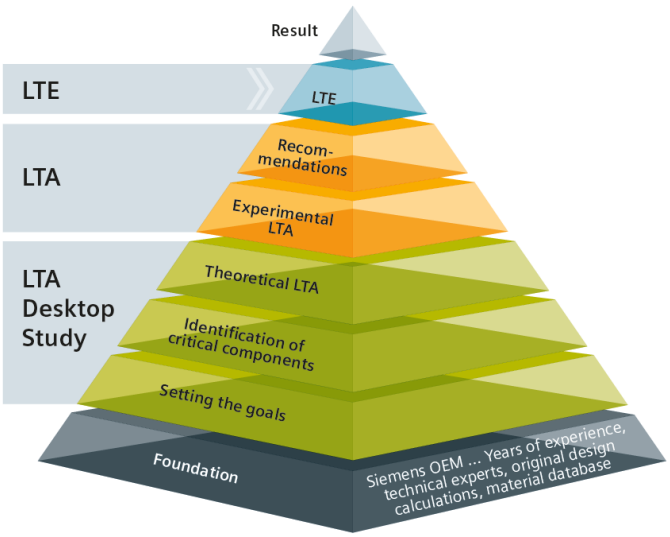


Figure 7: LTA/LTE Pyramide

LTA Desktop Study

A theoretical LTA Desktop study is the first step to take. The output of such a study will be unit specific activities for LTA and a suggested point in time for these activities.

The LTA Desktop study is recommended to be performed about two years before reaching the second major overhaul according to Siemens Energy maintenance program (after 100,000 EOH). Performing the LTA desktop study in that early stage allows additional recommended measures to the major overhaul to be implemented.

Step 1 Setting the Goals

We sit down with you to define your technical and economic goals, taking into consideration future operating conditions, output and availability. Preliminary cost estimates are made for lifetime extension on the basis of these goals.



Figure 8: Setting the goals

Step 2 Identification of critical components

A review of operating records, turbine history and design calculations are made to identify critical components. You as the customer are actively involved at this stage as well.

Step 3 Theoretical status and life Time assessment

Components identified in step 2 will be further analyzed in step 3. Complementary theoretical analyses are performed based on today's design criteria and Siemens Energy experience from similar units and components. To make the inspections more focused, they might be preceded by detailed temperature and stress analyses using FEM techniques. The assessment of remaining life time is made by engineers, supported by long-term laboratory tests and data from thousands of steam turbines in operation. All potentially critical components will be divided into three classes from a conservative point of view:

Class 1: High priority

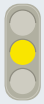


Actions needed

Risk for low reliability/availability/safety

Limited lifetime

Class 2:



Operation time have exceeded the design life time

Long term actions

Class 3:



No special action needed

Normal inspection/maintenance

The output of this step is a conservative theoretical Life Time Assessment and a specification of further recommended LTA work.

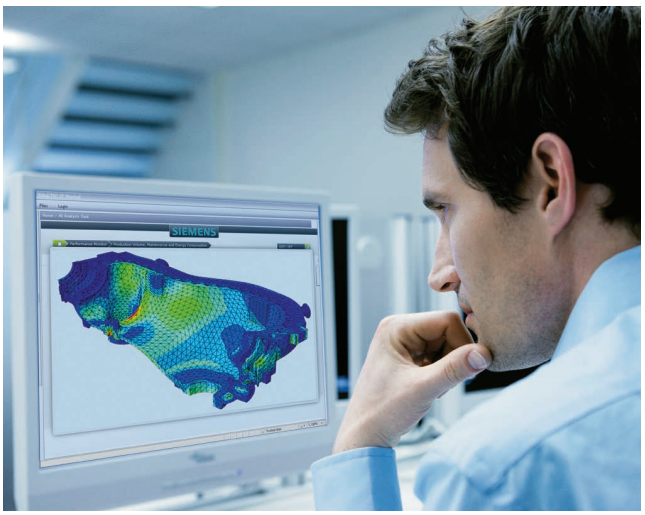


Figure 8: FEM analysis of the turbine casing

LTA

Step 4 Experimental status and Life TimeAssessment

Inspection and non-destructive testing (NDT) of critical components will be performed based on the LTA Desktop study. Common activities are:

- Inspections
- Dimension checks
- Magnetic particle test, liquid penetrant test, ultrasonic examination, eddy current inspection, phased arrays inspection, etc.
- Hardness tests
- Replica extraction
- Surface sampling

In most cases the specified activities are enough for a LTA, but in some cases more specific or even extended NDT- activities are needed. In-depth analysis, like FE-based calculations with modified material data or updated performance calculations, might be necessary for evaluation of the results. Investigations continue only as far as necessary to ensure the accuracy required.

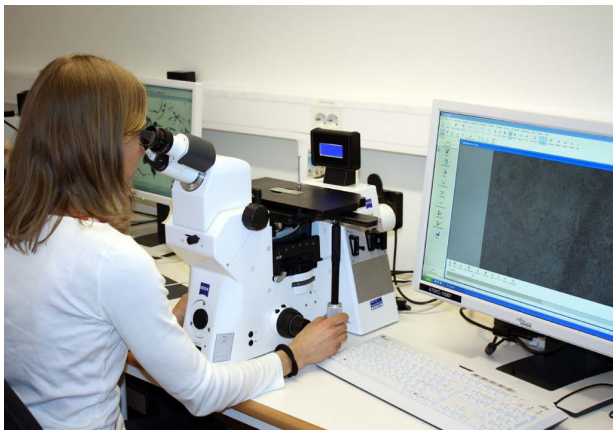


Figure 9: Evaluation of replicas in the laboratory. By analyzing the microstructure, deviations such as creep damages or thermal aging can be detected at an early stage.



Figure 10: Ultrasonic testing of bearings in the workshop

Step 5 Recommendations for Life Time Extension

All information collected during the LTA work form the basis of Siemens Energy' recommendation for LTE. For each component, a unique recommendation is specified:

- Return to service with no additional limitation
- Modify operating conditions
- Repair specific components
- Replace exhausted components
- Re-inspect at suitable time intervals

General Information

Each LTA/LTE-work is unique due to different initial conditions: design, material quality, turbine history or vision of the future. The deep knowledge and experience about the wide range of aging turbines allows us to give well founded recommendations. We continuously increase our knowledge on aging turbines in the Siemens Energy fleet by performing numerous annual LTA/LTE studies and longtime destructive testing in our laboratory. By doing destructive testing, it is possible for Siemens Energy to investigate and analyze material deviation and degradation through the components and compare the results with known parameters such as:

- Original material structure
- Operation temperature
- Operating hours
- Number of starts and stops
- Theoretical load level

LTE

Step 6 Life Time Extension

A life time extension plan is established by executing the recommended measures found in the LTA study. This means, for example, that parts will be replaced, repaired or reinspected. The recommended LTE work will be updated continuously and adapted to present customer needs.



Figure 11: Sand blasting



Figure 12: Repair works (welding)

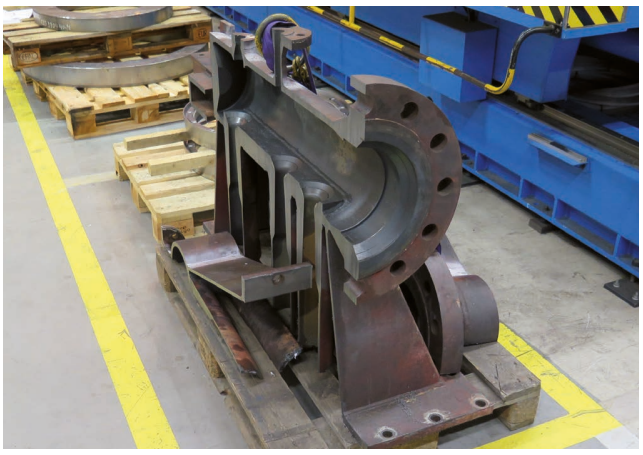


Figure 13: Valve casing divided into two halves to make internal inspection possible

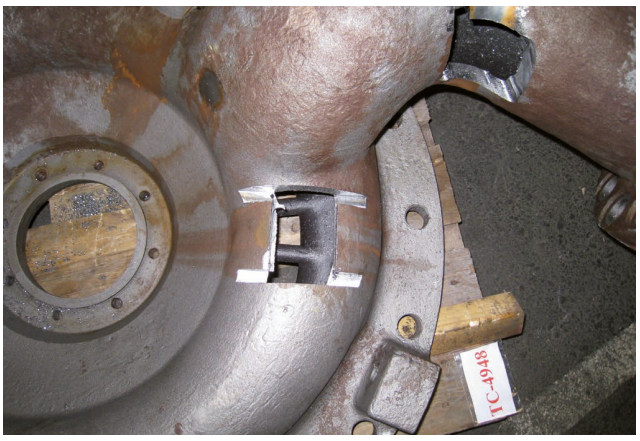


Figure 14: A scrapped steam chamber from an old marine turbine used for destructive testing

Case study

Aging steam turbines require your attention

- In operation since: 1983
- Operating hours: 154,000 h
- Number of starts: 310
- Steam temperature: 540 °C/1000 °F
- Steam pressure: 114 bar/1650 PSI

The goal was set in step 1, the client wanted to secure continued operation for at least 85,000 operating hours.The customer focused on high availability and the intention was continuous operation as long as possible, with the turbine originally designed for 100,000 operating hours. The results of the evaluation in steps 2-4, inspections and complementary non-destructive testing, were that most parts of the turbine were in good condition and the experimental status and LTA agreed with the theoretical. Further operation for 85,000 hours was considered possible for most components. Serious creep damages were, however, found in the inlet emergency stop valve (ESV) and the control valve (CV) casing. All cracks were grinded until no indications were visible and further investigations and inspections for LTE were recommended for the casing within one year, step 5. As part of the lifetime extension work, step 6, one year later the ESV and CV casings were tested with a magnetic particle test complemented by structure examination and hardness measurements. At this time, the serious creep damages had returned. The updated LTE recommendation was now to plan for a replacement and to evaluate the optimum operation manner to secure a low risk level until a new valve casing was manufactured. Based on a fracture mechanical calculation Siemens Energy recommended turbine operation with a decreased inlet temperature to minimize further creep damages until the new casing were available. After the old ESV and CV casing was replaced, the unit had no limitation for further operation over the requested period.



Figure 15: Meassuring the distance between turbine blades

Potential benefits of LTA/LTE are:

- High availability and Reliability of a turbine at the end of its design life
- Extension of the operating life of the turbine at limited investment cost
- Performance and efficiency increase

Published by

Siemens Energy Global GmbH & Co. KG
Industrial Applications
Freyeslebenstraße 1
91058 Erlangen, Germany

Siemens Energy Inc.
Industrial Applications
15375 Memorial Drive, Suite 700
Houston TX 77079, USA

For more information, please contact
our Siemens Energy Customer Support Center
Phone: +49 (0)911 6505 6505
Or +49 180 5 24 7000
(charges depending on provider)
E-Mail: support@siemens-energy.com
Web: siemens-energy.com/csc

Siemens Energy is a trademark licensed by Siemens AG.