

Modernization and retrofit concept for the Umm Al Nar East combined cycle power station

Preserving customers' investments in capital goods is one of the strategic market services offered by ABB, and to this end the company has developed project-specific retrofit concepts especially for older power generation plant. A prime example of such a modernization is the Umm Al Nar East (UANE) combined cycle power station in Abu Dhabi, UAE. UANE has two gas turbines of type GT13D, which together generate 140 MW of electrical energy, and heat-recovery boilers which supply steam to a seawater desalination plant with a capacity of 80 million liters of drinking water per day. After almost 20 years in operation, UANE is being modernized. To address the owner's concerns and minimize plant downtime, ABB has introduced Service, Operation and Rehabilitation (SOR) Key Account Management for Abu Dhabi. In the first phase of the modernization project, the static starting equipment was upgraded and the mechanical turbine governor replaced by the EGATROL electro-hydraulic control system. Also, the rotor of gas turbine 2 was retrofitted for a further 100,000 hours of service. The control and instrumentation equipment will be renewed in stages in the next phase of the SOR concept.

Abu Dhabi is the largest sheikhdom in the United Arab Emirates. The area around Umm Al Nar in Abu Dhabi is the site of numerous industrial facilities, 14 power plants with a total generation capacity of 1,200 MW, and 16 seawater desalination plants which are capable of producing 200 million liters of drinking water per day.

ABB built the 140-MW Umm Al Nar East (UANE) combined cycle power plant for the *Water and Electricity Department (WED)* of Abu Dhabi between 1976 and 1980. The

plant has two GT13 D gas turbines, two heat-recovery boilers and four auxiliary

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boilers. Seawater desalination plants connected downstream of the power station have a daily output of approximately 80 million liters of drinking water.

Later, in a consortium with Skoda of the Czech Republic and Voest Alpine of Austria, ABB was contracted to supply and commission all the electrical and I&C systems for the 160-MW Umm Al Nar West power station units 7 and 8.

Energy and water needs in Abu Dhabi

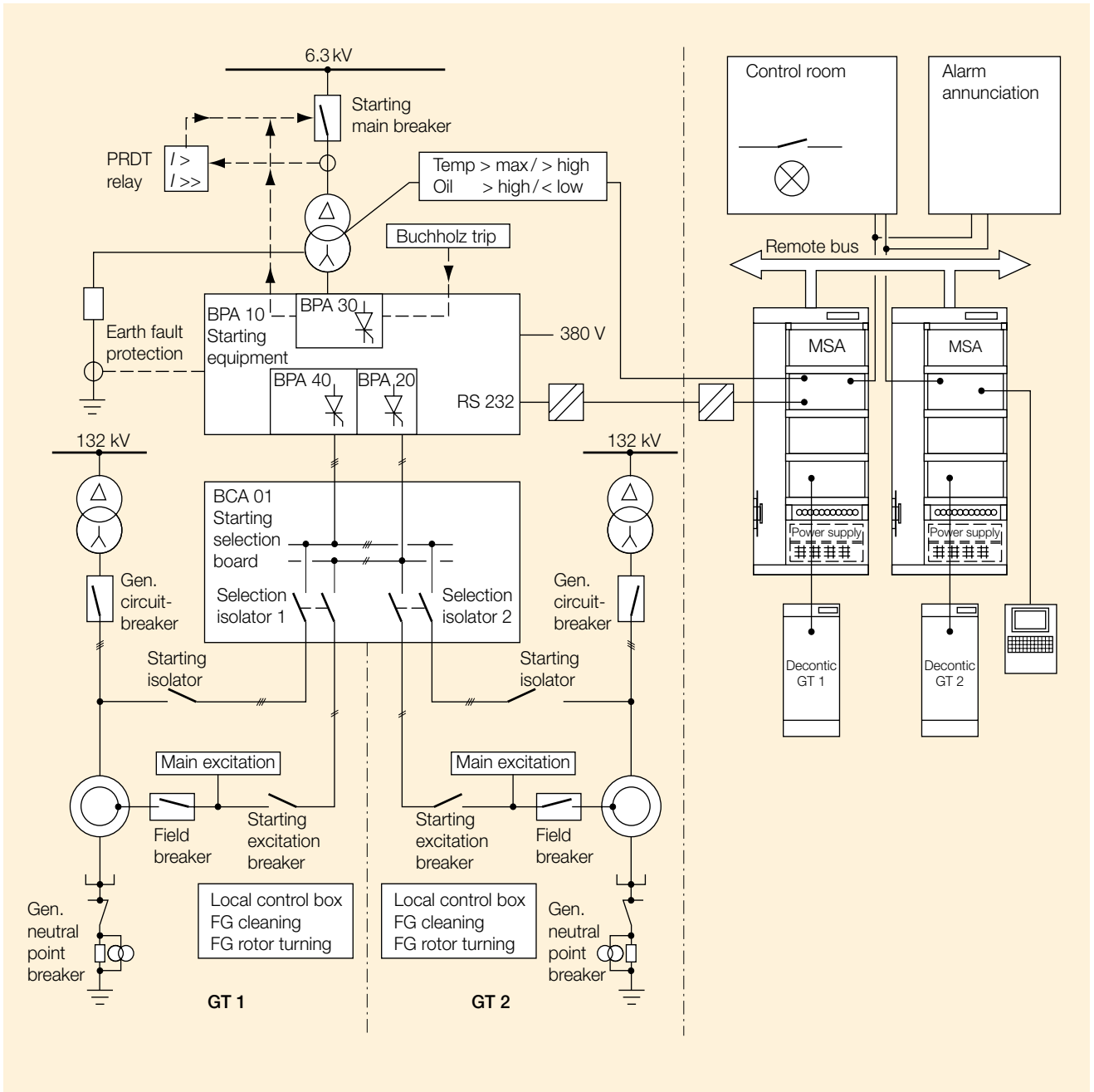
Demand for electrical energy in Abu Dhabi is greatest between June and September. During the other months, the energy needs are only about 30 to 40 percent of the figure during this peak season.

Demand for water from the seawater desalination plants, however, remains practically constant over the whole year. Because of this, the plants require a continuous supply of steam. The load factor of the gas turbines has to be adjusted to take account of this situation.

Infrastructural expansion calls for optimization of all resources

Demand for electrical energy is growing in parallel with the continuing expansion of Abu Dhabi's infrastructure. To meet the increased demand, it is necessary not only to build new power plants but also to ensure that the existing generating capacity is utilized to the full.

Most of the existing power stations are today between 15 and 20 years old, and their installed systems are no longer state of the art. Downtimes due to disturbances are relatively long and the necessarily short intervals between inspections are having a considerable impact on reliability and availability. In addition, spare parts for the older equipment are becoming increasingly difficult to obtain. WED consequently follows a policy of ongoing modernization and retrofitting of its power stations at Umm Al Nar.



Overview of the new static starting equipment installed in Umm Al Nar East

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Custom-designed concept for modernization and retrofitting

As a result of the comprehensive, long-term inspection and maintenance policy adopted by the WED power station management, the Umm Al Nar power stations are in excellent condition. This provides an ideal basis for further modernization and retrofit measures aimed at guaranteeing reliable

and proper operation of the plants for an additional 15 to 20 years.

Modernization and retrofit measures have the character of projects, and the rules laid down by the WED require consultants to be involved in the preparation of the tender specifications. With the usual tendering procedures, it would take 2 to 3 years to process such projects and place the orders. It goes without saying that this would not

allow the quick improvement in plant availability that is required.

Working closely together with WED, a highly flexible and efficient modernization and retrofit concept was developed based on Service, Operation and Rehabilitation (SOR) Key Account Management for Abu Dhabi. This splits the various modernization and retrofit projects into two categories. The first consists of OEM-related hardware

packages, including all the necessary engineering and documentation, while the second covers the erection and commissioning. The engineering packages are processed in the same way as normal OEM spare-parts orders; the erection and commissioning packages, on the other hand, are included in the maintenance contracts placed by WED at two-year intervals following the official invitations to tender.

Obviously, with an approach of this kind comprehensive specifications that accurately describe the deliveries and supplies have to be prepared. They provide a basis both for the direct enquiries made to the equipment vendors and for tendering for the maintenance contracts with detailed descriptions of the assembly work and commissioning.

The main goals of the SOR modernization and retrofit measures are:

- Optimization of the plant and plant component reliability
- Increased plant and plant component lifetime
- Minimization of the maintenance and inspection costs
- Significantly shorter erection and commissioning times
- Accurate scheduling and efficient project management to ensure that the work is carried out during routine inspection and preventive maintenance periods, thereby avoiding additional outages

To achieve these goals, careful and detailed advance planning, with all the project interfaces taken into consideration, is essential.

The subject of warranty is taken into account in that the normal warranty time of 1 year becomes applicable within the framework of the maintenance contracts on completion of commissioning. A precondition is that the installation work is performed by specialists provided by the OEM. This is also true when the OEM does not happen to be the general contractor awarded the overall retrofit project.

The custom-designed modernization projects for the Umm Al Nar East power plant show that retrofits of the described

kind can be carried out without long outages.

Static starting equipment renewed with minimum downtime

The new static starting equipment **1** is based on proven PROCONTROL P technology from ABB and provides the following functions:

- Starting and rotor turning
- Gas turbine maintenance capability, including the necessary measurements and measured-value processing
- Control of certain function groups, including the gas turbine control program, autonomous drives, turbine protection
- Communication with the thermal and electrical control rooms
- Alarm functions and protection interlocks

The scope of the supplies and services also included a new starting transformer and modification of the generator neutral point (eg, removal of the load angle transmitter and the converter supervising the start at the generator neutral).

Just 6 weeks were needed to install the static starting equipment, the actual downtime being not more than 2 weeks.

EGATROL improves reliability and efficiency

The two GT13D gas turbines in the Umm Al Nar East power station were previously controlled and monitored by mechanical governor systems **2**, many parts of which were subject to wear and tear and required regular maintenance. To improve the reliability and availability of the power plant they were replaced by gas turbine control systems of type EGATROL **3**.

EGATROL is an electro-hydraulic system, introduced in 1983 by ABB as standard in the GT13 gas turbine. It consists essentially of two parts – the electro-hydraulic control unit and the supervisory electronics – and controls and monitors all of the key functions involved in operating gas turbines.

As a result of converting to EGATROL,

the number of mechanical components was drastically reduced, with parts subject to wear and tear practically eliminated. Another advantage of EGATROL is that fewer electric drives are necessary. The process data are also easier to access, while its diagnostics functions help in trouble-shooting and the modular design simplifies the replacement of failed parts.

EGATROL is based on the proven PROCONTROL P power plant control system, with features that include:

- Standardized technology, allowing complete replacement of the I&C systems at a later date
- Reduction of interfaces to a minimum
- Good flexibility, thanks to the ease with which the program can be modified and adjusted on-line
- Requires only a small space
- Use of existing measured-value processing equipment
- Optimization supported by flexible, computerized control structures (eg, addition of disturbance variables, checking of the plausibility of process values, etc)
- Accurate, reproducible control values (for high transparency)

The EGATROL governor systems are controlled by means of process operator stations which carry out the signal conditioning and display the process data in the form of mimic, characteristic, profile or trend displays. Datalogging, archiving and project engineering are further tasks which can be carried out at the process operator stations.

Only minor adjustments to the existing process control were necessary as a result of changeover to the new systems. The EGATROL control units were modified to suit the connections on the site and tested in the factory prior to delivery. Additional equipment required by EGATROL includes 3 tachometers in the gearbox, and transmitters, etc, for measuring the ambient and exhaust-gas temperature and the compressor inlet and outlet pressure. The additional components necessitated only a limited extension of the alarm system. Certain adjustments were also necessary in the control

room. The two EGATROL systems were installed during the winter of 1997 and in early 1998.

Upgrading the rotor for a longer lifetime

Why upgrade?

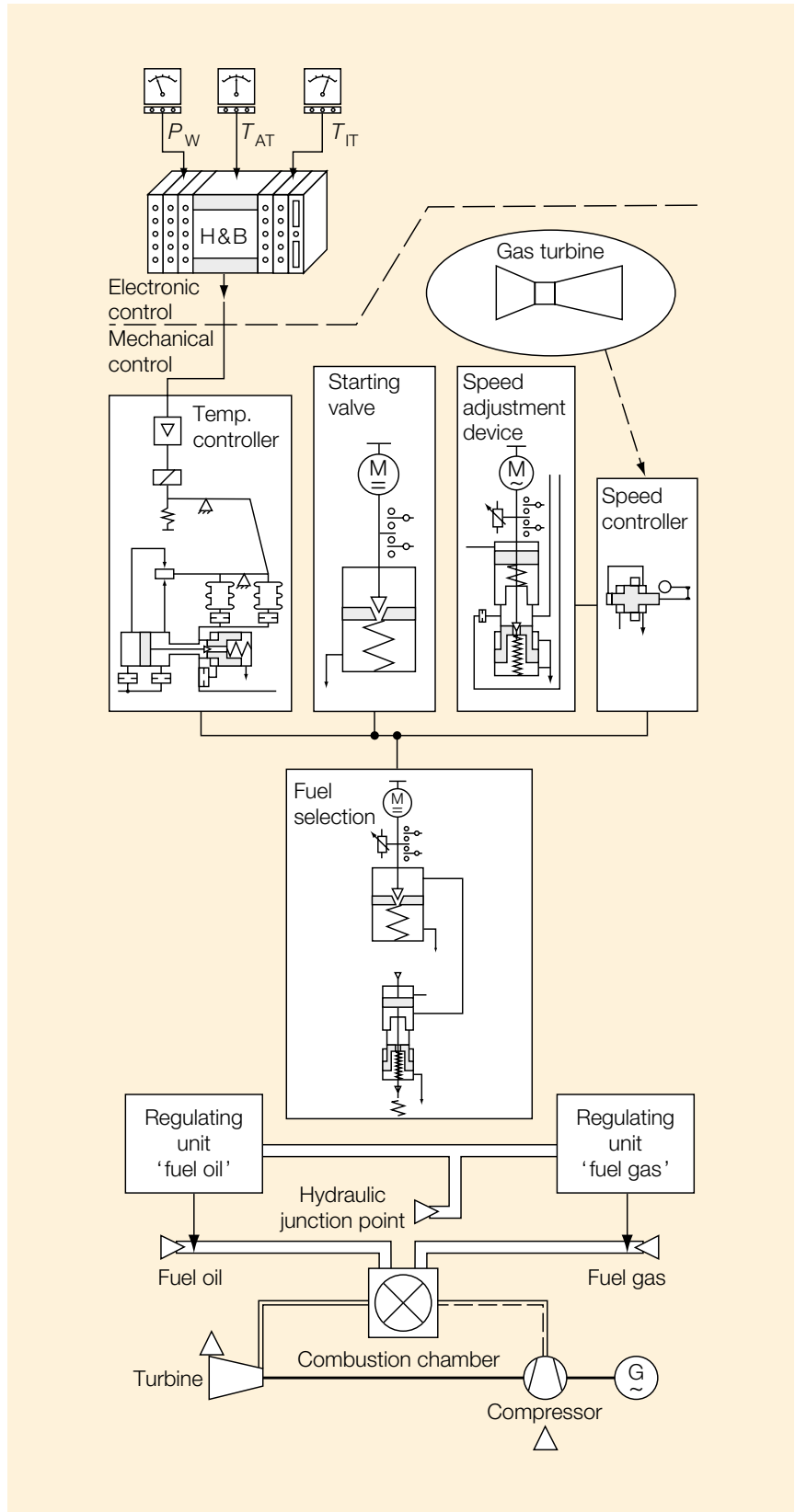
The operation of complex machines or installations always involves some parts wearing faster than others. The object of upgrading is to increase the running time of a gas turbine or a power plant by replacing partly worn parts before the end of their lifetime in order to preserve the original financial investment and continue to benefit from it. This calls for a well-balanced concept – a compromise in which the worn components are replaced as early as is necessary, but also as late as possible. Upgrading is an optimal way of increasing the operating lifetime of machines by 20 to 30 percent.

Lifetime analyses allow operators to decide which components have to be replaced. ABB gas turbine engineering and development departments have carried out a joint study of lifetime prediction and evaluated the remaining lifetime for the hot-gas components and rotors of gas turbines. Despite the many parameters, realistic predictions are possible.

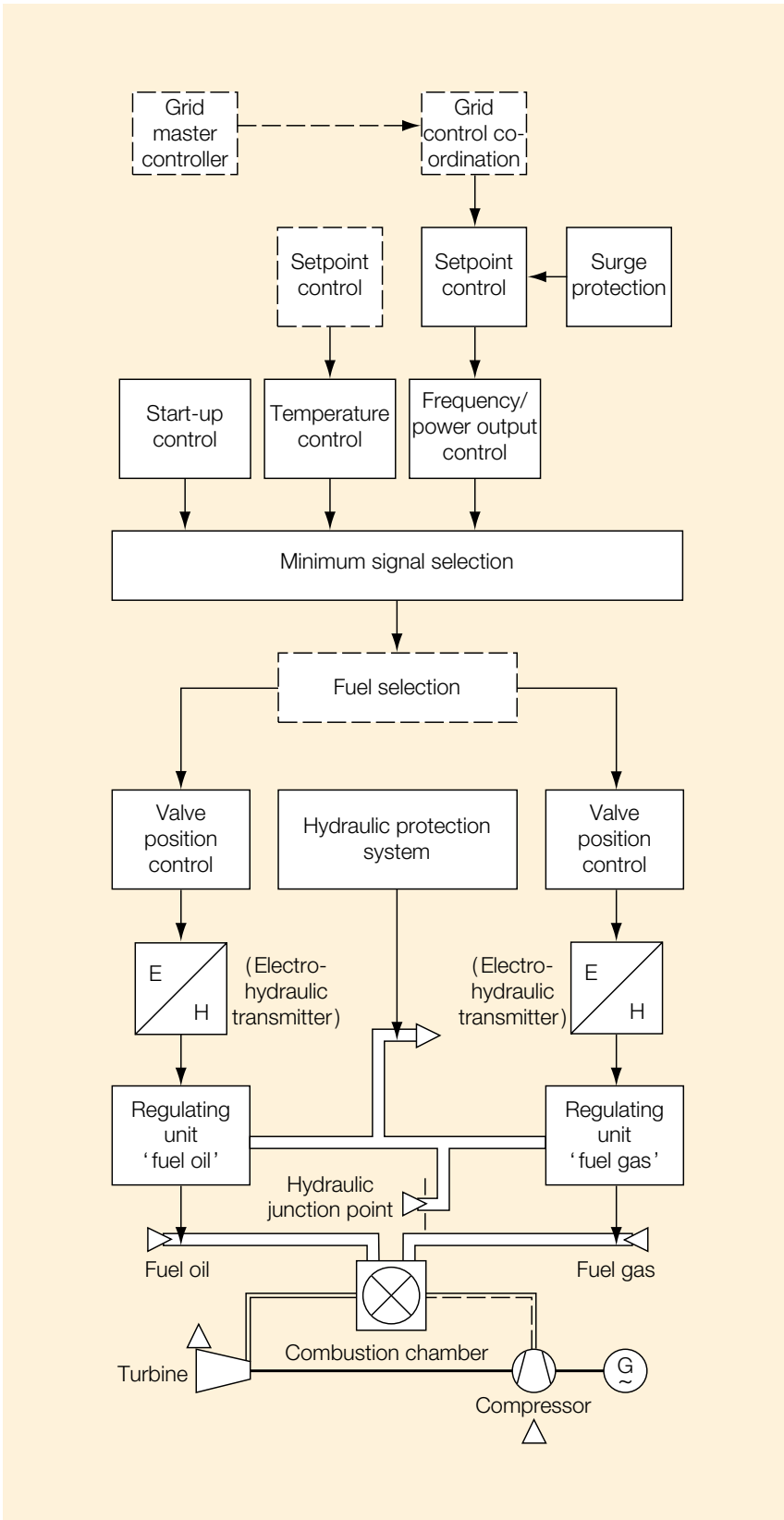
How can the remaining lifetime be accurately predicted?

In traditional lifetime analysis, the results of the evaluation of the expired part of the lifetime are accounted for by including the time-related materials stressing at high temperatures. Among the factors recorded are the stress level fatigue due to the stress cycle, and the crack endurance. Other time-dependent factors considered are the operating mode and the turbine's running hours, ie the dynamic operating behaviour of the installation.

ABB has developed new computational methods that are based on the results of traditional lifetime analysis and the company's experience with gas turbines. One of



Mechanical gas turbine governor system that was replaced. It has many parts which are subject to wear and tear, and therefore requires regular maintenance.



EGATROL electro-hydraulic gas turbine governor system. It has two parts – the electro-hydraulic control unit and the supervisory electronics.

these, the Evaluated Operating Hours (EOH) formula for assessing the depletion in lifetime of the blading, cabling and hot-gas components, considers the temperature level, normal and rapid starts, and transient conditions. The EOH formula also takes special account of the effect that depleted lifetime due to long-term stress and load-cycle-induced alternating stress has on the hot-gas components.

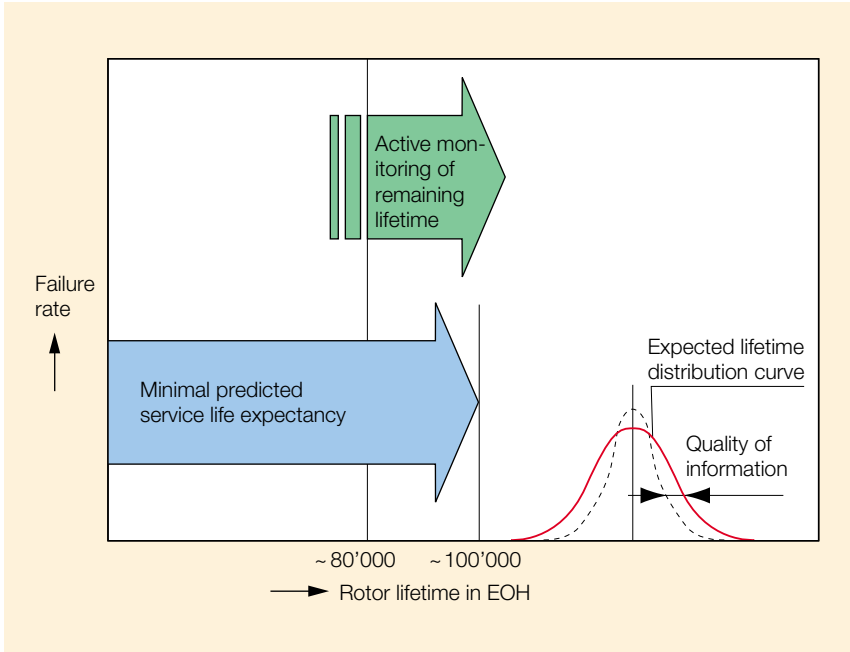
ABB has also developed special software for evaluating the remaining lifetime of gas turbine rotors. The main factors considered here are the thermal loading and fatigue. The expired lifetime is computed from the fatigue components, with account taken of the number of fast starts, emergency trips and warm starts. The difference between the determined expired lifetime and the acceptable total fatigue provides the remaining lifetime **4**.

Remaining lifetime analyses were performed for the UANE gas turbines 1 and 2 and their main components. On the basis of the results, upgrade proposals, such as the replacement of the entire gas turbine rotor and the blade carrier of gas turbine 2, were made. After careful preplanning, these components were ordered by WED and subsequently installed in place of the existing components during the next major inspection, which was scheduled to be carried out before the summer peak in 1997. Thus, no extra outages were involved.

Rotor refurbishment – the right technical and economical solution

To avoid having to scrap old rotors **5a**, ABB has developed and successfully tried a method in which the compressor part of the old rotor is reconditioned and afterwards welded onto a new gas turbine rotor part. A visual inspection is therefore necessary to assess the degradation of the surfaces of the compressor. This assessment supplies the input data required for the subsequent non-destructive test **5b**. The results of the test, which take account of the service-related loading of the rotor, determine whether the compressor part of the rotor has to be recon-

3



Gas turbine rotor lifetime risk assessment, given in evaluated operating hours (EOH) 4

ditioned or not. As a rule, reconditioning involves only minor repairs having to be carried out. After refurbishing, the rotor can be operated for a further lifetime of 100,000 EOH.

Training of the operating personnel is an important part of the SOR concept

To gain maximum benefit from the newly installed systems, the operating staff have to

be included as partners during all phases of the project.

Within the framework of the SOR concept, emphasis is therefore placed on integrating the customer's engineers in all processes, including the initial presentation of the project, and especially during the preparation of the specifications. Acceptance testing of the ordered hardware and engineering packages by the client's staff usually takes place in the factory prior to delivery of

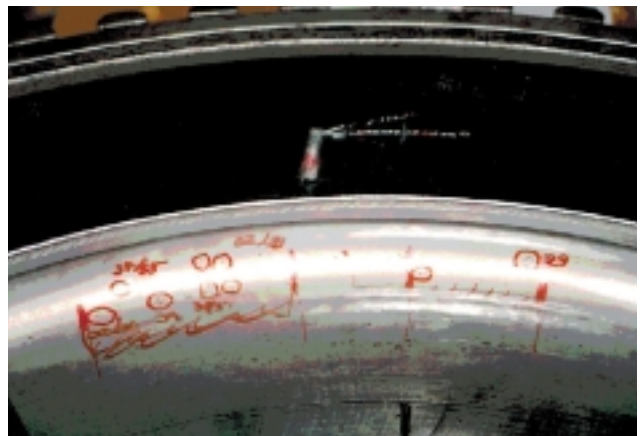
the packages to the site. As a rule, the acceptance tests are combined with comprehensive instruction at ABB training centers. Often, these courses are followed by visits to other power plants to give the customer's engineers a chance to see similar upgrade and modernization project measures. Another integral part of the SOR concept is a visit to ABB research and manufacturing facilities.

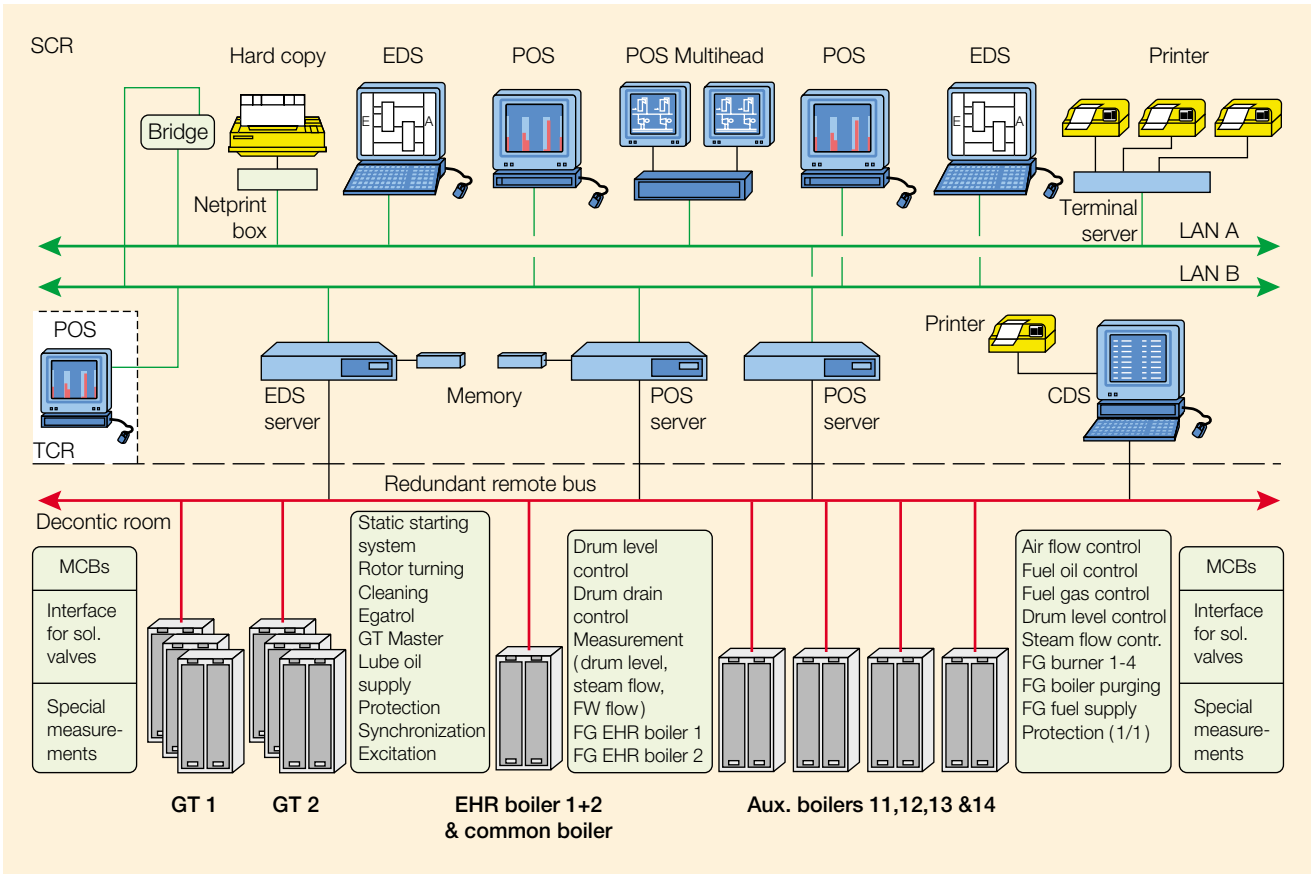
The next step is an exact check of the delivered hardware and software packages in the power plant to ensure that they are complete. Also important is proper storage of the equipment and materials needed for the assembly and commissioning.

Assembly and commissioning accompanied by hands-on training, with the customer's engineers working closely together with ABB specialists. This practice ensures maximum transfer of know-how. The training is rounded off with special courses for the operating and maintenance staff in the power plant.

In addition, annual seminars will be held especially for the WED in Abu Dhabi to keep the operating staff up to date in all technical matters. The customer can also make his own additions to the agenda, which specialists from ABB will then address. As a rule, these seminars last two days, giving the customer's engineers and ABB's specialist staff sufficient time and opportunity to discuss the questions that arise.

Parts of a gas turbine rotor during the reconditioning process (a) and non-destructive testing (b) 5





Configuration of the new PROCONTROL P process control system due to be installed in stages in the Umm Al Nar East power station.

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Plant modernization as an ongoing management assignment

The Umm Al Nar East power plant still has a large potential for improvement and modernization. All of the work carried out so far is designed to allow further retrofit components to be installed at any time in the future. This foresight can be seen in the implementation of the upgrade measures as platforms upon which the later modernization steps can be based.

The UANE management regards step-by-step modernization as an ongoing assignment. Already planned is the replacement of the remaining I&C equipment **6** as well as an overhaul of the entire DC supply system.

The old process computer systems in the Umm Al Nar West units 7 & 8 should also be replaced by modern ABB systems,

and so allow all of the Umm Al Nar units to be linked together in the same data network.

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