P91 & P92 Issues Faced by High Temperature Plants

Your chance to be a part of two new Group Sponsored Projects

Project 1: Development & Demonstration of the next generation of Inspection, Monitoring & Life Assessment of P91 & P92 components

The 9Cr martensitic steel P91 has now been in use in the power generation industry for over 20 years, although the use of P91 became more widespread only about 10 years ago and that of its tungsten strengthened stronger version P92 even more recently. Over this time there have been a number of incidents of cracking and failure in components made from these steels. Thick section components have generally been failing by Type IV cracking associated with welds. One problem with Type IV failure has been that the cracking may start sub-surface and cannot always be detected by easy to use and more economical techniques such as MPI, UT, replication etc. The cracking may only emerge at the surface near the last leg of its journey.

P91 and P92 steels have further problems in that unlike the low alloy ferritic steels operating in the creep regime, the more easily visible changes such as spherodisation and break down of the microstructure at the scale that can be seen under an optical microscope or even under an SEM does not occur in these steels. To make matters worse and life assessment more difficult it is now fairly well established that unlike the traditional low alloy steels high Cr martensitic steels do not necessarily go through the stages of creep cavity initiation → cavity growth → micro-cracking → macro-cracking → failure. In 9Cr martensitic steels the stages may be reduced to: creep cavity initiation → cavity growth → failure with little warning. Another difference between the traditional low alloy steels and 9Cr steels is that the cavity size in 9Cr steels can be of nanometre level for the early period of service thus making cavity detection and quantification by traditional means difficult until later in life. This means that for the safe operation of P91 and P92 components and for the ability to take remedial steps in time it is important that: a) we can observe cavity at an early stage (starting from perhaps about 20% of life), b) can measure and relate cavity density, size etc. to remaining life, c) can observe or monitor creep cavity damage inside the component wall (not just at the surface only) by perhaps more sensitive ultrasonic testing techniques, etc.

*NEW WEBSITE*

Come and visit our shiny new website and see our full list of products & services at: www.etd-consulting.com
PROJECT DETAILS - Project still opened to join:

ETD has started this new Group Sponsored Project (GSP) on the further development and validation of newer and more innovative inspection and monitoring techniques for P91 and P92 steels and interpreting these results/data for integrity and life assessment. This is the Phase 2 of an earlier GSP where Phase 1 involved developing and selecting the most promising NDE techniques which will now be validated in feature tests backed up by standard laboratory specimen test data. The results of Phase 2 work will help build accurate relationships of different damage parameters with component remaining life and thus improve plant operator’s confidence in the long term safe operation of high Cr martensitic steels.

This two-year duration project will involve testing of P91 (and some P92) welded pipes – performing inspection and monitoring of these pipes using novel NDE techniques which include those shown below.

1. Potential Drop (PD)
This is a specially developed electrical resistance measurement apparatus that uses a combination of alternating and direct current methods. It has been demonstrated in the Phase 1 project that the increase in PD can be related to the increase in creep cavity damage. This technique will thus be used to monitor creep cavity damage in the test pipes and some of the standard test specimens. This together with the other techniques used in this project will be aimed at making life assessment possible. The PD technique can be further developed for on-line monitoring of damage levels in critical locations of the plant.

2. Portable Scanning Force Microscope (SFM)
The (SFM) is a development on the traditionally laboratory based Atomic Force Microscope (AFM) that allows the technology to be used in a plant environment to produce nano-scale resolution images of comparable or better detail than Scanning Electron Microscope (SEM) images.
Note: Further details of the SFM can be found later in this Newsletter.

3. Ultrasonic Velocity Change Method
Creep damage, especially sub-surface, can often be detected non-destructively by measuring changes in the UT velocity. In general, longitudinal wave velocity through a component wall will decrease with creep cavitation damage in the wall.

4. Electric Discharge Sampling Equipment (EDSE)
The EDSE is a new ‘boat sampler’ which can cut small specimens out of thick section components for miniature specimen testing. This is an essential part of the assessment toolbox for this project. More details on EDSE are provided later in this newsletter.

5. Small Punch Testing
The above EDSE can be used to cut out specimens for small punch testing and miniature creep, fatigue or tensile testing for more accurate quantitative life assessment of older plants. The results of small punch testing have been shown to be comparable to conventional creep tests but require a database of virgin material properties for reliable comparison that is acceptable to operators.

6. Laser Guided Precision Hardness Tester: This newly developed portable hardness tester will be used for the hardness profiling of HAZ, parent and weld metals and relate these to the remaining life.

For more information and how to join just please contact: Dr Ahmed Shibli at ashibli@etd-consulting.com
Project 2: Creep Rupture Strength of ‘Abnormal P91’ Base & Weld Metals

Do you know the safe operating life of aberrant / abnormal P91 if you find it in your plant – as often found in plants worldwide? This project has been started to answer this question.

Many utilities and plants have been discovering ‘abnormal’ (or ‘aberrant’) P91 base metal and welded joints in their plants. Although it is now well known that heat treatment is critical in achieving full strength in high Cr martensitic steels, it is clear that for various reasons many materials suppliers, manufacturers or welding companies have failed to realise this criticality. As a result, there is a worldwide problem with P91 base metals and/or whole welded joints that have not been heat treated to specifications and/or best practices, resulting in hardness below the acceptable limit and/or the microstructure is not in the correct, fully martensitic condition. In addition, it has been found that deviations from optimal chemical composition can also result in abnormal microstructural conditions.

Many abnormal P91 components/welds have only been found some years after entering service, either during scheduled inspection outages or sometimes because there has been a premature failure. Not all of the abnormal components/welds can be replaced in the immediate future and many will have to remain in service indefinitely. However, this presents a very serious problem because the plant owners / operators do not know how to treat these components in the absence of any material data or guidelines.

BE A PART OF ETD’S NEW INDUSTRY SPONSORED PROJECT

There is an urgent need to obtain creep rupture data that can be used to estimate the long-term strength of abnormal P91 materials and welds found in plant. There could be considerable variation in the strength level of different materials/welds as a result of the different ways in which heat treatment of base metal and/or welds may deviate from, and sometimes within, the specification requirements. The objective of this project is to carry out stress rupture testing of abnormal P91 base metals and welds, which have been incorrectly heat-treated to produce a number of abnormal conditions (over-tempered, under-tempered etc). Tests will be of durations up to 30,000 hours in order to obtain stress rupture data that can be used for predicting the long-term strength of the materials/welds, so that plant operators can establish the safe and reliable operating lifetime of their components.

For more information and how to join please contact: Dr David Robertson at drobertson@etd-consulting.com
ETD’s Plant Cycling Cost & Performance Analysis Services

Market-driven changes in the electricity industry worldwide, due to increased competition, increased renewable energy contribution, and the need for costs reduction, have lead to power plants (both Conventional and Combined Cycle) increasingly being subjected to cyclic operation (load following, two-shifting, or providing reserve capacity).

However, cyclic operation causes additional plant damage, and subsequent problems – requiring enhanced inspection, monitoring, staff training, repair/maintenance, and therefore additional costs. Reliability can suffer in cases where older, less efficient plants (originally designed for base load operation) are changed over to cyclic operation.

*ETD can help utility owners and operators understand the implications of cyclic operation, which include technical issues and additional costs associated with increased outage rates, reduced availability and reliability etc.*

ETD has significant expertise in performing cycling cost and performance analysis of power plants. The analysis we conduct can estimate the current and future maintenance costs and performance impact caused by plant cycling operation through top down and bottom up analysis.

Maintenance / failure history, operating, cost and reliability data is typically collected for the units under study, which is used to determine correlations between reliability performance, operating mode, maintenance expenditure and component life - both historically and predicted for future operation. We would typically perform in-depth condition assessment, including water chemistry and corrosion analysis, to identify key engineering risks which support the estimates of future costs and performance, and therefore the results generated are also of use to Engineers and technical staff.

The results of ETD’s cycling analysis studies can be used for various applications such as to provide more accurate data for planning maintenance budgets, for conducting market modeling within the system and to provide greater knowledge of a plants potential schedule rankings.

*ETD Consulting has extensive global experience of cycling related issues and provides expert advice to minimise risks associated with cycling in the future.*

ETD is one of the few companies which has developed its own models and methodologies for plant costs analysis – both top down and more detailed bottom up.

*We can send you our standard proposal for work on your plant and costs involved which can then be further adopted and tailored to your needs.*

For further information please contact: Eng. Ms Feroza Akther  fakther@etd-consulting.com
New Licensing opportunities for Crackfit© - ETD’s class leading defect/crack assessment procedure/ software

Crackfit© is a procedure and software developed by ETD in collaboration with European industry. It was previously available for purchase only but is now also available on short term (1 to 2 months) or longer lease - and at a fraction of the purchase price!

Crackfit© can be used for solving your problems in assessing Fitness-for-Service, safe remaining life of newly manufactured / in-service components. These may have been found, or could have the possibility to contain manufacturing or service induced defects / cracks. If in the process you are convinced that Crackfit© can help you in future then you can decide to either hire it again as needed or take the option to purchase outright.

Apart from the technical excellence of Crackfit©, it significantly reduces the time required to carry out assessments, in some cases from weeks to days! It also comes with a separate crack initiation and growth database for many materials of interest to industry.

Crackfit© deals with the life assessment of various components which contain defects such as lack of fusion /penetration in welds (defects at weld toes), internal and external surface emerging or embedded defects in straight pipes, defects in pipe bends, defects at stress concentrations such as sharp corners (T-pieces, nozzles), defects in plates and can be used for analysing standard laboratory fracture mechanics type specimens.

The software is user friendly for industry engineers who would like to carry out defect assessments without having to go through the different established codes or country / in-house defect assessment practices. Procedures including BS7910, the French code RCC-MR A16 and the European procedure ‘HIDA’ are available as software options. The software allows for failure analysis (fast fracture, plastic collapse and ligament rupture) and the evaluation of damage mechanisms such as creep, fatigue, and creep-fatigue interaction.

In reality, input data required for the defect assessment can be varied and may be obtained from well-scattered data, tending to produce a large deviation of the input values, hence reducing confidence in the quality of the results. A sensitivity analysis is therefore always recommended. For a more sophisticated evaluation, the option of performing a probabilistic analysis is also available when using the software. Crackfit© accommodates both types of analysis by allowing the user to simply choose the confidence level for different types of input data.

For further information please contact: Engr. Ms Feroza Akther fakther@etd-consulting.com
e-Lifing or electronic life assessment is a Compendium of Power Plant Life Assessment Procedures compiled by the European and Japanese experts. e-Lifing is a very large (1360 pages), comprehensive, up-to-date and ‘first of its kind’ Compendium of Lifing Procedures & Methodologies (both deterministic and probabilistic) for Power Plant Boilers, Steam Turbines and Heat Recovery Steam Generators (HRSGs).

“e-Lifing’ is not only a great tool for life assessment but also excellent tool for our engineers’ training in the current and state of the art plant integrity and life assessment issues and methodologies’” - Feedback from one of the users.

Now being used by utilities in the UK, Germany, Belgium, Canada, South Africa.

For details, purchase or use of any of the above please contact: enquiries@etd-consulting.com

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e-Atlas e or electronic Atlas -database of ageing microstructures

‘e-Atlas’ opens a great opportunity to compare the microstructure of your in-service components with the reference microstructure (and calculated remaining life) from e-Atlas of plant up to 40+ years old. This is an interactive software where over 10,000 microstructure images (with known history of component operating parameters and life) of various materials including their constituents (HAZ, base metal, weld etc.) can be called side by side and compared with the replica microstructure of your plant components to give an indication of plant remaining life. E-Atlas also calculates the remaining life based on A-Parameter.

‘e-Atlas’ is a unique database which incorporates a large number of replicas (10,000+) together with their full plant and lifing history. It is currently being used by power & process industry in the UK, Belgium and Italy. Now material specific pdf versions of e-Atlas are available at much reduced cost.
EDSE: Innovation for Asset Management

Reliable and quantitative assessment of plant component integrity and remaining life may involve testing or metallography of in-service material which may require in-situ machining of very small samples from thick section components by the use of appropriate sampling equipment, without incurring life-limiting damage to these components.

As already presented in the feature article of this newsletter, the EDSE (Electrical Discharge Sampling Equipment) produces ‘wedge’ shaped samples with specimen thickness ranging from 1 to 10mm for exactly this purpose, and can do it in as little as 1.5 hours.

EDSE is available to purchase or ETD can be hired to perform the sampling to your specifications.
Please contact: ashibli@etd-consulting.com

Portable Scanning Force Microscopy (SFM)

Another innovative tool that ETD is using to inspect component integrity and perform remaining life assessment. SFM connected to a laptop provides instant images of nano and micro damage (creep cavitation, fatigue, corrosion etc) at an incredible high resolution and magnification using its own sophisticated software analysis to provide life assessment information on fast track basis. This portable tool is more powerful than an SEM and is aimed at replacing replication. Both pressure vessels and turbine rotors have been studied in a number of European and some Asian plants. The materials studied have included 9Cr martensitic steels (such as P91 - where early stage nano level cavitation cannot be resolved using traditional replication), low alloy pressure vessel steels and 1CrMoV rotor steels.

SFM images before (top) and after etching - Graphs show cavity depth & surface irregularities along the line scan.

The two image on right hand side show SFM mounted on a turbine and on a vertical pipe.

SFM is now available for sale with full accompanying software and training. ETD also provides it as a service to industry worldwide. Its small size means that SFM can be taken to and used anywhere in the world.

For further information please contact: ashibli@etd-consulting.com
Group Sponsored / Multi-Client Projects - AVAILABLE TO JOIN

In addition to the feature articles on P91 projects, ETD Consulting regularly launches new Group Sponsored Projects (GSPs). GSPs are the most popular and economical projects for industry involvement - each project sponsor only pays a fraction of the total project cost but benefits from the full results. And yet the responsibility for the deliverables lies with one organisation (ETD). The projects can be joined at any stage of their execution although those who join early have more opportunities for making sure that the project deliverables are more relevant to their needs.

Preparation of Power Plant Commissioning Guidelines: ETD has formulated two proposals for preparing detailed and comprehensive Guidelines for the Commissioning of: a) CCGT and, b) conventional power plants.

Integrity and Life Assessment of Very Old Power Plants: Many power plants in Europe, Japan and elsewhere are now getting very old (40 years or more) and owners need to know their integrity and safe remaining life. However, there is not much data available for such plants. This project aims to develop techniques and methodologies needed to fill this gap.

Risk-Based Boiler Tube Failure Management Guidelines: This project was completed recently for a number of industry sponsors. However, ETD Consulting has now undertaken to increase the database and involve more plants. So if you are interested in participating and providing you Guidelines specifically aimed at your plant(s) then this is the project for you.

For details please write in the first instance to: enquiries@etd-consulting.com

P91 User Group – ETD’s expert knowledge and support service

What are the issues?
P91 steel does not appear to show creep voids (due to the nano size of cavitation damage) when inspected with the traditional NDE techniques until late in life. Thus new inspection techniques, quality assurance procedures and life assessment methodologies etc. are needed. In-service cracking and failure of P91 components can often be traced back to tempering time & temperature or post-weld heat treatment issues.

Why is a ‘P91 Users Group’ necessary?
One way of successfully managing the performance and life of P/T91 components is to draw upon the continued learning and experience of existing producers, fabricators and users of the material – encompassing plant operators, and the research community.

What are the objectives of the ‘International P91 User’s Group’ (P91UG)?
The idea was first discussed in 2005 in a meeting organised in London involving P91 experts, plant manufacturers and operators. The aim of P91UG is to discuss the concerns of P/T91 steel producers, power plant/HRSG manufacturers, plant owners/operators, and also nuclear and petrochemical industry users/ potential users. The is thus a program supporting industry, that collects, critically analyses, and disseminates the latest data, information and industry experience with P91 steel, with input from Users around the world. Information is passed on to members through a series of regular reports that provide state-of-the-art knowledge and procedures on P91 usage, welding, fabrication, quality checks, inspection, life assessment, repair and codes.

For more information and to join the P91 Users Group, please contact: Dr David Robertson drobertson@etd-consulting.com
ETD’s on-site services continue to go from strength to strength in 2014, the team can still be found roving across Europe, the Middle East and Asia performing non-destructive inspection on various plant components, including replication on a wide array of materials from the traditional carbon steels to the more modern martensitics such as P91- so grab them early to make sure you are covered during your next outage.

ETD is fully equipped with borescope, hardness tester, UT, Electrical Discharge Sampling Equipment (EDSE), Portable Scanning Force Microscopy (SFM) and replication equipment which means that most of your on-site inspection and life assessment/extension requirements can be taken care of by one single entity consisting of highly skilled metallurgists, mechanical engineers and fracture mechanics experts.

**ETD is not associated to any manufacturer or plant owner so can provide truly independent advice.**
Summary of ETD’s Consulting Services for Power & Process Plant

Backed up by state-of-the-art Tools & Methodologies developed in collaboration with international industry

Plant Integrity/ Life Assessment/ Extension

On-Site Replication/ Hardness/ UT/ Metallography

Fitness-for-Service (FFS)

Piping Stress Analysis (Caesar II)

Finite Element Analysis

Materials Advice & Support with Data/ Standards/ Procedures
(Low Alloy Steels, P23, P24, 9-12Cr Martensitic Steels, Stainless and Super Stainless Steels, Ni-based Alloys)

Welding Advice & Support with Data/ Standards/ Procedures

Weld & Weld Repair Guidance & Assessment

Root Cause Failure Analysis

Creep/ Fatigue/ Corrosion Analysis

Crack Assessment (both low and high temperature)

Design Review & Improvement especially for Cyclic Capability of Plants incl. CCGTs/HRSGs

Expert Witness

Support With Plant Outage Activities

Risk Based Management/ Inspection/ Maintenance

Benchmarking (both technical and financial)

Guidance on Component Repair/Replacement

Specialists support with P91, P92 & other Steels & Alloys

Boiler tube failure management

Flow Assisted Corrosion, Water Chemistry + much more.
### Available Guidelines and Reports from Group Sponsored Projects

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<th>Title</th>
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<td>Survey of on-line monitoring techniques and recommendations for best practice</td>
<td>1076-gsp-55</td>
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<tr>
<td>Survey of advanced inspection techniques and recommendations for best practice</td>
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<tr>
<td>Guidelines for inspection, monitoring, repair and maintenance of HRSGs</td>
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<tr>
<td>- Based on review of worldwide plant and research experience</td>
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<td>Review of the use of new high strength steels in conventional and HRSG boilers R&amp;D and Plant experience</td>
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<td>Damage to power plant due to two-shifting / cyclic operation &amp; guideline for best practice</td>
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<td>Damage to CCGTs due to Cyclic Operation- Operational, Technical &amp; Cost Issues</td>
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<tr>
<td>Review of materials, data, plant experience &amp; new developments for design and lifing of high temperature plant, including the datasheets</td>
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<td>- provided as 4 separate sub-projects/ Reports, all of which are complete and available for purchase:</td>
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<tr>
<td>1. Low alloy ferritic</td>
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<td>Preservation Guidelines for CCGT &amp; Conventional Power Plant during Short and Long Term Shutdowns ETD Project No.1274-gsp-proj13</td>
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For purchase or use of any of the above please contact: enquiries@etd-consulting.com
In addition to the ‘open-to-all’ training courses and conferences that ETD regularly organises, it also provides tailor-made ‘training-on-demand’ or ‘On-Site’ courses’ for industry engineers worldwide. In the past such training courses have included topics such as: Plant life assessment (boiler, turbine, process plant), Boiler design, P91, P92, P23, P24, Weld repair, Assessment of components containing defects/ cracks, Plant operation and maintenance, Asset management, Weld repairs, HRSGs, CCGTs etc.

**THREE 2 DAY PLANT LIFE MANAGEMENT FOUNDATION (LMF) COURSES**

Three individual but inter-linked 2-day Plant Life Management Foundation Courses (LMF courses), giving delegates an in-depth understanding of Plant Life Management issues. Attendees may attend one, two or all three courses, depending on their individual training needs.

Tuesday, June 17, 2014 – Tuesday, June 24, 2014
9:00am

**2 DAY TRAINING COURSE ON P91 & P92 ISSUES**

A 2 day Training Course on P91 & P92 issues, which will give delegates a detailed understanding of those steels and their behaviours.

Tuesday, October 14, 2014 – Wednesday, October 15, 2014
9:30am

**2 DAY SEMINAR - USE & ABUSE OF P91 & P92 STEELS - REGISTRATION & CALL FOR PRESENTATIONS**

A 2 day seminar by leading experts on the Use & Abuse of P91 & P92 Steels - looking at real-life experiences of those materials in industry.

Thursday, October 16, 2014 – Friday, October 17, 2014
9:00am

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**Two on-site courses held this year**

Two ‘made-to-measure’ courses have been organised so far this year - one for Saline Water Conversion Company (SWCC) in Saudi Arabia and the 2nd for Eskom in South Africa.

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**For up-to-date information**

Please visit our website (new events may be added from time to time), or write to: enquiries@etd-consulting.com
ETD Consulting will be exhibiting at the Power-Gen Europe. We are located at Hall 6, Booth 37.

Come and try out our Crackfit crack assessment software, as well as see a video of our EDSE in action - we'll also have EDSE cut out ‘boat samples’ to show and much more.

Come and visit for a friendly chat about any plant issues you are currently facing or how ETD Consulting can help you.

ETD Consulting is sponsoring this Power Outage & Preservation Conference and will be presenting two papers on the following topics.

The Conference programme will soon be finalised and put on the ETD website.

**Paper 1 - Short and Long-term Preservation of Power Plant Boilers**

This paper will be based on the recently prepared ETD’s Guidelines on the Preservation of CCGT and Conventional Power Plants during short- and long-term shutdowns. It will cover the topics such as:

- Preventing corrosion and minimising impacts to plant reliability.
- Implementing procedures to accommodate rapid start-up.
- Considering the entire plant when developing preservation procedures.

**Paper 2 - Power Plant Cyclic Operation - Cost and Performance Implications**

The key issues to discuss will include:

- Cost modeling for power plant operation and maintenance when operating in flexible mode.
- Plant start up cost analysis using top down and bottom up approaches.
- Development of new techniques for bottom up cost assessment.
- Probabilistic cost analysis.
- Plant critical components life assessment and its relationship to O & M costs.
- Plant benchmarking and reduction of outages and costs.
- New initiatives for bottom up and top down cost analysis of power plants.
ETD Membership – Guaranteed and Dedicated Service

In response to a continuous flow of informal requests from our industrial clients worldwide (in specific from power and process plants) for technical advice and assistance, ETD provides an International Membership Scheme to support its clients.

A request for technical advice and assistance, for example, could be on matters related to plant operation, maintenance, inspection, monitoring, materials (the traditional materials and the new higher strength martensitic steels, super stainless steels and Ni-based alloys), welding, weld repairs, crack assessment, component integrity and life extension, reliable data sources, sensitivity analysis, probabilistic assessment etc.

Requests for advice and assistance are in addition to the formal projects that ETD regularly undertakes for its individual clients or groups of clients. The requests for technical advice/assistance can require ETD effort ranging from a few hours to a day or more at a time.

Whenever you have a technical problem and need reliable expert advice, then who better to contact than a member of staff at ETD?

We have a network of experts from plant operation, maintenance and inspection through to materials, welding, component integrity assessment and life extension, to probabilistic assessment, risk based management, and so on. With access to experts from Europe, USA, Japan and elsewhere, that ETD have regularly depended on for many years, we can provide you with the best and most reliable advice to solve your everyday plant problems and thus increase your plant reliability and profitability. And this is not all! Depending on the level of membership, in addition to the technical support and assistance, we can offer:

• Reduced subscription to one of our new, existing or completed Group Sponsored Projects (GSPs)
• Staff training packages
• Independent review of technical reports e.g. written internally by your company, or by outside experts
• Bespoke consultancy services tailored to your requirements.

The three levels of membership available are:

Foundation  Intermediate  Advanced

For details please contact Membership Secretary:
Eng. Ms Feroza Akther  fakther@etd-consulting.com

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