Guidance on the preservation and recommissioning of existing combined cycle gas turbine (CCGT) plant

energy institute

GUIDANCE ON THE PRESERVATION AND RECOMMISSIONING OF EXISTING COMBINED CYCLE GAS TURBINE (CCGT) PLANT

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FOREWORD

The first generation of combined cycle gas turbine (CCGT) plant entered the power generation market in the early 1990s. However, older CCGT plant has become displaced by higher efficiency emergent plant and, coupled with competition from renewable sources, carbon pricing and levies, the first generation CCGTs have been displaced and are no longer commercially viable to operate.

These combined effects have led to a number of UK CCGT power plants being taken out of service and considered for preservation. Introduced in 2014, the new UK capacity market enables a structure in which owners of CCGT plant can bid into the capacity auctions and, if successful, can return a preserved plant back into commercial service. However, the commercial payments are partially based upon delivery of a high reliability when called upon to operate, with high penalties for failing to achieve designated return to service times. A fundamental principle is therefore to ensure that the plant is preserved in a condition where it does not deteriorate, allowing it to be returned to service and fully recommissioned at minimum cost within a known and often tight timescale, but also safely and reliably.

The preservation and recommissioning of CCGT plant is not straightforward. As the outage period of a plant is extended so is the requirement to protect against the damage mechanisms caused by condensation, corrosion and from seizure due to lack of intended use. There is also a variety of other issues to consider, related to service contracts, cost, planning, and the ability to recommission plant quickly and when needed.

Split into two parts, this publication provides generalised guidance on the safe and efficient preservation and recommissioning of existing CCGT plant. It is based on typical CCGT commissioning programmes and provides:

– An overview of the principles behind preservation and recommissioning.
– Guidance on how to effectively preserve key plant (mechanical and electronic) and return these to service.
– Checklists for conducting routine activities during preservation.
– Example schedules for preservation and recommissioning.
– Example costs.
– General guidance covering aspects of recommissioning including the systematic proof testing of the plant protection systems and the testing of mechanical trips (overspeed, pressure relief, etc.) and plant trips and interlocks compliant with the functional safety and safety integrity level (SIL) requirements (as identified).

This publication is intended for managers wishing to gain a general understanding of CCGT preservation and recommissioning, and can be used by the power generation industry to capture and consolidate the current industry knowledge on the safe preservation and recommissioning of CCGT plant. It can also be utilised by the plant owner/operator to capture specific knowledge and risk rank each task with the degree to which those risks are known and mitigated against for their CCGT plant.

Note that this publication focuses on technical aspects and guidance for good industry practice, albeit at a fairly high level. Furthermore, it does not purport to include all the necessary provisions of a contract or licence to operate. Full compliance with this guidance cannot confer immunity from all legal, regulatory and environmental obligations, including safety, environmental regulations and permits and licences.

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1 INTRODUCTION

This publication provides guidance on the preservation and recommissioning of combined cycle gas turbine (CCGT) power plant.

The word 'preservation' is used extensively throughout this publication. **Preservation techniques** are those techniques which could be applied to shut down and then preserve a plant in order to prevent or reduce deterioration when out of service. **Preserved plant** is plant which has been shut down, and has had (or could have) these techniques applied to it. Hence, when a managerial decision is made to categorise the plant as short-term and long-term 'cold', 'reserve', 'shut down', etc., a decision has been made regarding the extent of preservation techniques to be applied.

Preservation of plant is therefore a) the process by which a plant is taken out of service/shut down (using preservation techniques) and b) stored in a suitable state (as preserved plant) with the intention of being returned to service at a later point. This is more colloquially known as 'mothballing', but can also be referred to as 'lay-up', 'shutdown' and 'outage'. When the plant is recommissioned, it is brought out of a state of preservation and into a state that can safely return to service.

1.1 HISTORICAL PERSPECTIVE

The first generation of CCGTs entered the power generation market in the early 1990s, following the sanctioning of natural gas for use in power generation. With an average thermal efficiency above 45 %, CCGT plant had lower running costs than coal-fired plant and was used for base load power generation. For over 10 years the so called 'dash for gas' saw over 20 GW of new CCGT plant being built in the UK. During this time, original equipment manufacturers (OEMs) continued to make rapid advances in CCGT design and materials, increasing the thermal efficiency of second generation power plant to over 55 %, and third generation to 60 %.

The thermal efficiency is at base load, but this can be traded against other improvements in plant flexibility (ramp rates, minimum stable generation, frequency response, etc.) to enable the operator to make the most of the changing market conditions. With the increase in demand for natural gas for CCGT plant both in the UK and Europe, gas prices gradually increased for new plant. After their initial 10 years of base load operation, the first generation CCGT plant became displaced by the higher efficiency emergent plant, causing a change to more flexible operation. Typically this comprised running during the daytime and shutting down over night and weekends.

More recently, with the entrance of renewable power generation, principally wind turbines, biomass, waste to energy and solar power, the first generation CCGTs have been displaced and are no longer commercially viable to operate.

A carbon price floor for the power sector was introduced by the UK Government in the March 2011 Budget. The mechanism introduced carbon price support (CPS) rates with effect from 1 April 2013 as additional rates under the Climate Change Levy (CCL) legislation. CPS was designed to give a stable carbon price signal to low carbon generation investors, whilst introducing an additional tax on the UK CCGT fleet, payable per tonne of carbon dioxide (CO_2) emitted when burning fossil fuels. The combined effects of lower load profiles and higher costs associated with CPS have led to a number of UK CCGT power plants being taken out of service and considered for preservation.

Introduced in 2014, the new capacity market enables a structure in which owners of CCGT plant can bid into capacity auctions and, if successful, can return a preserved plant back into commercial service. However, the commercial payments are partially based upon delivery of a high reliability when called upon to operate, with high penalties for failing to achieve designated return-to-service times. A fundamental principle is therefore to ensure that the plant is preserved in a condition where it does not deteriorate, allowing it to be returned to service and fully recommissioned at minimum cost within a known and often tight timescale.

1.2 PRESERVATION PROBLEMS, RECOMMISSIONING CHALLENGES

The preservation and recommissioning of CCGT plant is, understandably, not straightforward. As the outage period of a plant is extended so is the requirement to protect against the damage mechanisms caused by condensation, corrosion and from seizure due to lack of intended use. The plant preservation techniques and storage of equipment necessary to mitigate against asset deterioration are primarily a matter of good engineering practice, design and good housekeeping. There is also a variety of other issues to consider, related to service contracts, cost, planning, and the ability to recommission plant quickly and when needed.

Typical issues to consider prior to preservation of plant include:

- When is the correct time to implement preservation measures?
- How long is the plant expected to remain in a preserved state?
- What method of plant preservation should be adopted?
- How much will it cost to preserve the plant?
- Should staff levels be reduced to a minimal preservation team?
- Which site services should be isolated?
- Which site services should remain in service?
- How much notice is needed to cancel major contracts?
- Which contracts should be retained?
- What additional preservation equipment should be purchased?
- Should a plant preservation master plan be produced?
- Should any additional frost protection measures be implemented?
- How will the results of ongoing plant inspections be recorded?

Likewise, typical issues to consider when recommissioning the plant from a state of preservation include:

- How much will it cost to recommission the plant?
- Will the plant require a statutory outage prior to return-to-service?
- When should the recruitment of new staff begin?
- How to organise appropriate training for new staff?
- Which items of plant are considered safety critical systems?
- How many staff are needed for recommissioning?
- When should major contracts be renewed?
- Do any plant items need to be replaced due to obsolescence?
- How long will it take to return the plant into commercial operation?

– Do any OEM design changes, to improve on availability and start times (capacity market driven), need to be implemented?

Despite the challenges involved in successful preservation and recommissioning of plant, within the UK there have been a number of CCGT plants preserved for one or two years at minimal cost and with minimum maintenance within a manned and operational station. This publication draws upon the experience gained from these examples, providing good practice guidance on preservation techniques and safe recommissioning of existing CCGT plant.

1.3 SCOPE

This publication attempts to answer the questions in 1.2, and other questions, by drawing upon lessons learned from the preservation and recommissioning of existing CCGT UK power plants. In doing so, it provides:

– An overview of the principles behind preservation and recommissioning.
– Guidance on how to effectively preserve key plant (mechanical and electronic) and return these to service.
– Checklists for conducting routine activities during preservation.
– Example schedules for preservation and recommissioning.
– Example costs.
– Guidance covering aspects of recommissioning including the systematic proof testing of the plant protection systems and the testing of mechanical trips (overspeed, pressure relief, etc.) and plant trips and interlocks compliant with the functional safety and safety integrity level (SIL) requirements (as identified).

It is intended primarily for managers considering or overseeing the preservation and recommissioning of a CCGT plant. The guidance provided is deliberately high-level and generalised. It should be noted that this publication focuses on technical aspects and guidance for good industry practice and does not purport to include all the necessary provisions of a contract or licence to operate, nor does it purport to provide all of the technical detail that an engineer would want or need. The reader should be aware that they are themselves responsible for its correct consideration and application within their own recommissioning management and operational procedures. Full compliance with this guidance cannot confer immunity from all legal, regulatory and environmental obligations, including safety, environmental regulations and permits and licences.

What plant is the guidance applicable to?

Understandably, different sites will differ in the plant they contain. The guidance provided, and the associated plant preservation schedules, are therefore based on an example 'generic plant'. The example generic plant consists of:

– Mechanical plant:
  – gas (or combustion) turbine (GT/CT);
  – cooling systems;
  – heat recovery steam generator (HRSG);
  – fuel systems;
  – steam turbine, and
  – high pressure (HP), cold and hot and low pressure (LP) steam.

- Pipework and pressure relief:
  - fire systems;
  - drainage systems;
  - HP and LP feedwater system;
  - bulk chemical storage;
  - closed circuit cooling water system, and
  - water dosing systems.
- Electrical plant:
  - generator stators;
  - general electrical systems;
  - generator rotors;
  - switchgear;
  - generator auxiliaries;
  - motors 11 Kv, 3,3 Kv, and 415 V;
  - transformers (oil cooled and air cooled);
  - batteries;
  - grid system connections, and
  - uninterruptable power supplies (UPSs).
- Control and instrumentation:
  - steam turbine (ST) and GT governor systems;
  - distributed control system (DCS) and control and monitoring systems;
  - plant protection systems;
  - instrument air systems;
  - alarm systems;
  - safety related systems;
  - heating, ventilation and air conditioning (HVAC) systems;
  - trace heating;
  - gas and fire detection systems, and
  - telecoms and network systems.
- Civil buildings and structures:
  - gate-house and security (including perimeter fences);
  - offices, main buildings, roof and structure;
  - ancillary buildings, and
  - plant infrastructure.

As such, where a plant deviates from this list, the reader should bear in mind that recommendations may differ or may otherwise not be covered in this publication.

Lastly, safety and the establishing of good safety practice is central to this publication, including the handover documentation.